Department of Veterans Affairs

Rehabilitation Research and Development Service

A Clinical Guide

Physical Fitness
A Guide for Individuals with Lower Limb Loss

Ernest M. Burgess, M.D. and Albert Rappoport, C.P.

Department of Veterans Affairs
Veterans Health Administration
Rehabilitation Research and Development Service
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Physical Fitness
A Guide for Individuals with Lower limb Loss

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BEFORE YOU READ THIS BOOK

Physical Fitness: A Guide for Individuals with Lower Limb Loss does not attempt to cover every possible exercise, nor is it to be considered a text on exercise physiology. Other excellent source texts have been written and are recommended for further information. They are listed in the Bibliography. This book does offer a solid foundation in understanding the importance of physical conditioning and the ways in which persons with an amputation can achieve fitness by adapting their prosthesis to the exercise regime and/or following a conditioning program without it. Several amputation levels are covered and variations on how the desired exercises can be accomplished are included.

Please note that when an above-knee (AK) amputee is shown performing a certain exercise or activity, it should not be construed as the way every AK amputee must attempt to perform that exercise—or that every amputee is capable of performing it. Starting with the proper surgery, training, and prosthetics, many activities are possible but are not to be expected of all amputees. The individual amputee and trainer should explore the opportunities for exercise based on that which the amputee feels comfortable with and confident in doing. The program can build from there and, in time, reach higher fitness goals.

The purpose of this book is to inform amputees that they can design a routine that would allow them to work out independently, after becoming familiar with activities from a trained instructor. The exercises shown are performed with equipment that does not require additional assistance. The use of free weights may require an observer (as it would for any able-bodied lifter) when performing a heavy routine. The use of this equipment, commonly found in health clubs across the country, allows lower limb amputees to feel confident in integrating into that mainstream environment knowing that they can also work the same muscle groups, although not always in the same manner. Certain exercises may need to be adapted; however, the same muscles mentioned are used and the amputee can achieve the same fitness levels as persons who have no amputation. If the amputee has the desire, this book will assist in finding the way to higher levels of physical conditioning.

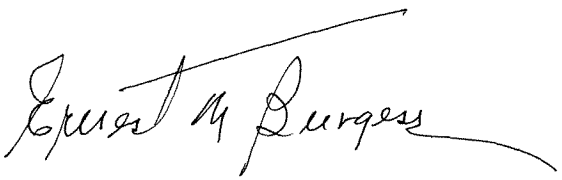
PREFACE

"There is no greater glory for a man as long as he lives than that which he wins by his own hands and feet." This quotation from Homer's *Odyssey* reminds us of our long history in valuing physical accomplishments of the body. The joy of exercise, what it does for the body, the mind, and the soul cannot be measured in material terms. How does one describe the crisp wind in one's face when flying through weightless powder snow down a steep alpine slope? Or the thrill of arriving at the summit of a cliff, or a mountain just scaled? Or riding the crest of a wave on a foaming surf? Or the exhilaration of kicking a soccer ball past the diving goalie? These and so many more expressions of physical activity, of endurance, of body awareness, and of competition add up to happiness. The sense of well-being, of physical fitness, of the ability to compete in sports with others, of body awareness, and of body control are all a major and indispensable part of *joie de vivre.*

As a society, we cannot and must not overlook this great and critical component of the good life for the millions of physically disabled among us.

Limitation of physical performance is particularly poignant in the case of the amputee. Not only is structural physical capacity diminished by limb loss, the amputee also faces the obvious visible evidence of a lack of wholeness. The physical deficit, therefore, is not only structural, it is psychosocial as well. In the final analysis, only the amputee can understand and appreciate the meaning of limb loss. The sense of body image altered by the amputation presents a daily hurdle. Physical accomplishment lowers that hurdle. As the boundaries of the possible are increased, what seemed impossible can become possible, and the difficult can become easy; then, the easy becomes pleasant.

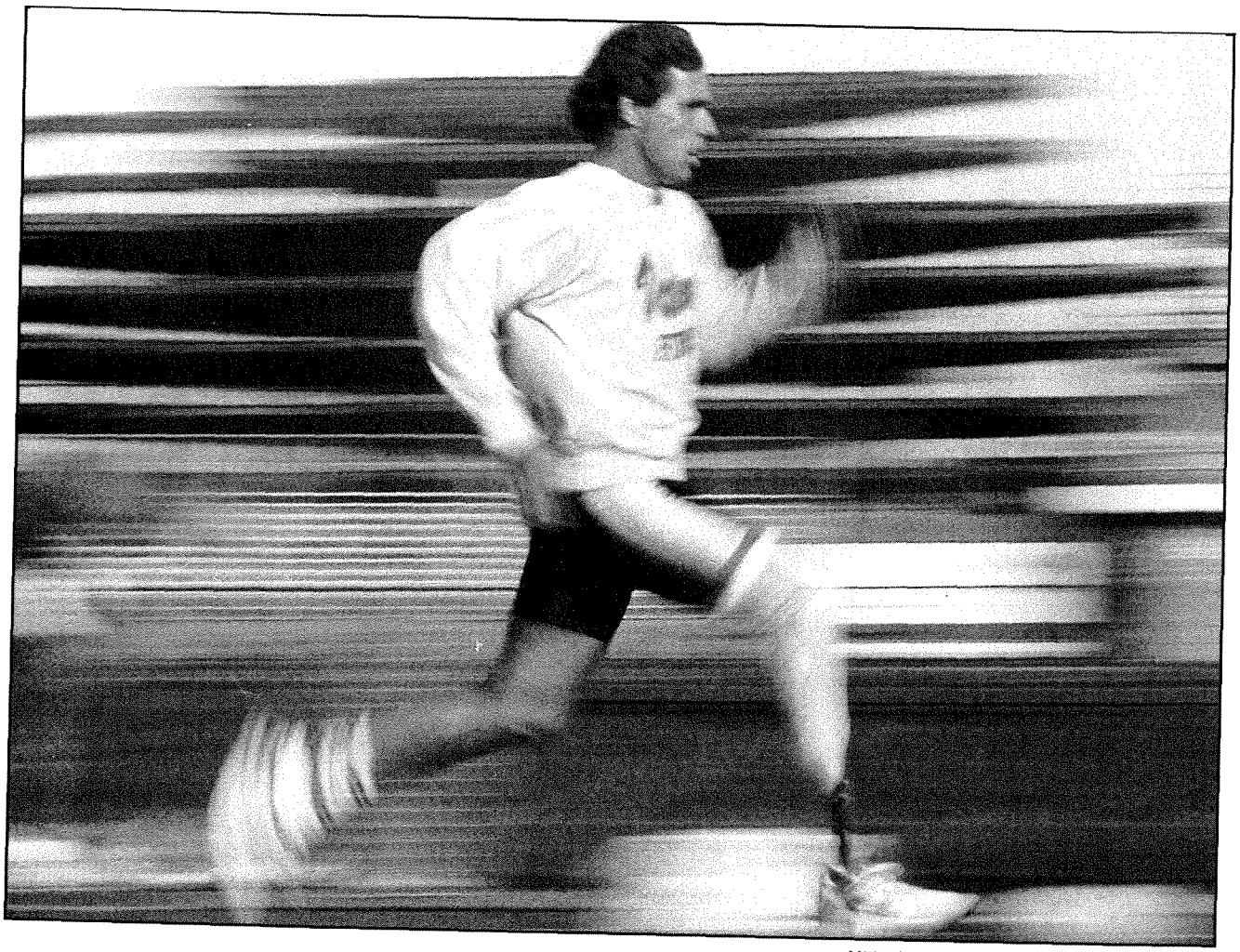
This book is written to help the many among us with limb loss, young and old, to experience the joy of physical recreation and sport; personal sport and competitive sport. It is dedicated to the profiles in courage which they exhibit each and every day.



Ernest M. Burgess, M.D.

PART ONE

PHYSICAL FITNESS GUIDELINES



NEWSDAY/J. CONRAD WILLIAMS, JR.

1

INTRODUCTION

This book presents a guide for helping people who have had a lower limb amputation realize fully their physical capabilities. It is intended as a resource for the clinical team in rehabilitation management, and provides guidelines for designing a realistic, safe, and enjoyable program of physical conditioning and exercise.

Its goal is to stimulate a lifelong interest in fitness, not only for a sense of physical and mental well-being, but to improve longevity. Studies indicate that individuals with amputations are more prone to develop cardiovascular diseases and have a somewhat shorter life expectancy than the general population. These circumstances may be the result of inactivity based on perceived restrictions due to a disability and a sedentary lifestyle, predisposing these individuals to earlier development of degenerative diseases.

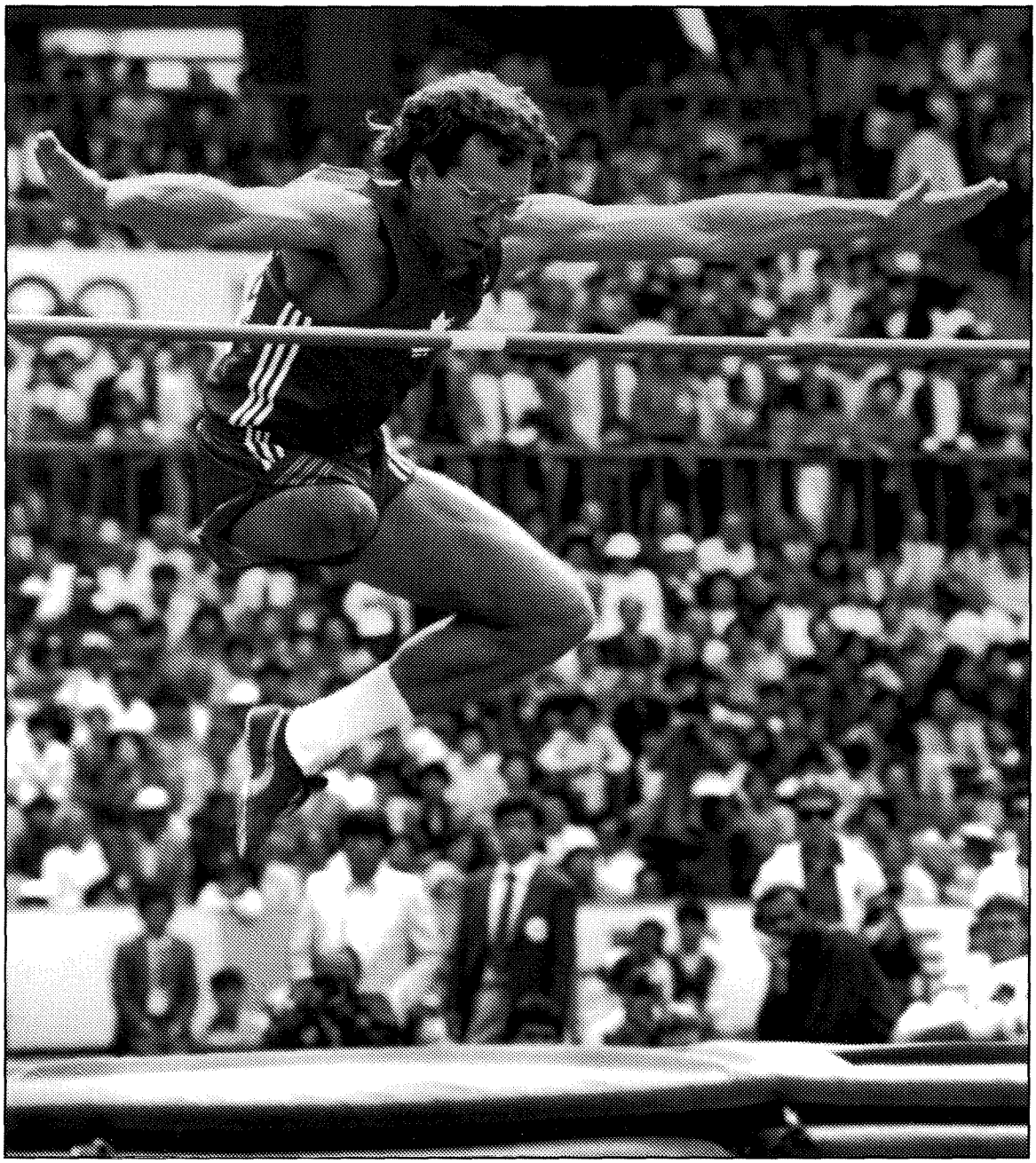
It is no longer considered wise to discourage or limit physical activity merely because an individual has had an amputation. The amputation can often be a stimulus to better physical fitness, even for older people. Exercise is a form of treatment in the rehabilitation process. Unless there is a valid medical reason for limiting even the gentler forms of exercise, physical disability should not be considered a reason for avoiding exercise.

By far the majority of amputations performed in America and the Western world today are caused by medical conditions: primarily, occlusive diseases of the arteries to the limbs and diabetes. For the most part these amputations occur in older people. A program of physical fitness, consistent with the state of health and physical capabilities of these older people, will surely enhance their quality of life for the remaining years. While the fitness programs described in this text are described and demonstrated, in general, for the younger physically active person, they will provide guidelines for those who are older and less active. The courage and physical capabilities described here provide an inspiration to all with lower limb loss. This positive rehabilitation message supersedes in some ways the actual mechanics of physical fitness outlined. The message is one of hope, accomplishment, and resolve.

The major concern of people of all ages who have undergone a lower limb amputation has been whether or not they would be able to regain their previous level of physical activity. This need not be a primary concern. Modern prosthetic technology will allow many individuals a recovery of function almost equal to pre-amputation potential. Persons with an amputation can not only participate in sports but can in many cases participate in those sports with their nondisabled teammates.

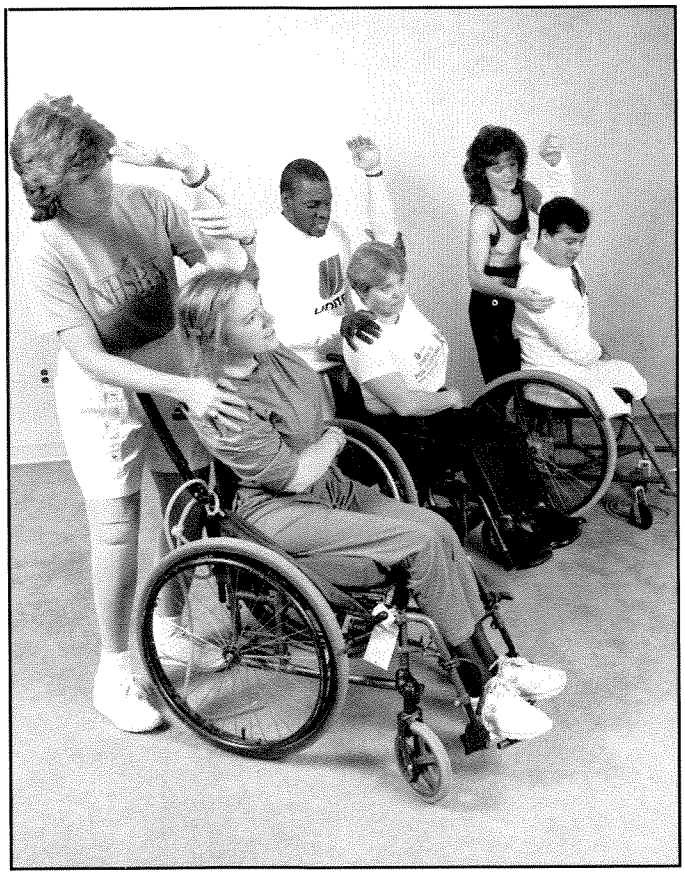
Competitive sports activities among people with disabilities are held throughout the world. Performance is impressive: a person with a lower limb amputation has run 100 meters in 11.73 seconds, another a 26-mile marathon in less than 3 1/2 hours. Disabled athletes also compete in organized sports events with nondisabled athletes and often surpass them.

The exercises and many of the sports activities



REUTERS/BETTMANN NEWSPHOTOS

Canadian athlete Arnold Boldt leaps over the high jump bar to win a gold medal at the 1988 Paralympic Games in Seoul, Korea.



RICHARD LAKIN/NHS, WASHINGTON, DC
A variety of disabled individuals participate in the National Handicapped Sports fitness clinics across the country.

illustrated in this book are performed by young people with a lower limb amputation. Thus, it may seem that the book is primarily directed toward young adults. That is not the intent. It is equally important—in fact, probably more important—that older people be concerned about physical fitness. Often, increasing age implies decreasing activity. This is particularly true in those with lower limb amputation.

Studies of the effects of moderate exercise on older people have repeatedly indicated that careful stretching can significantly improve the range of motion of joints and that the mineral content of bone can be increased. Aerobic exercise will stimulate greater blood flow to the body and brain, which will increase acuity and improve reflex time.

Most of the exercises and sports activities presented in this book can be performed and enjoyed by persons of all ages who are in good health. The first step is a complete medical review, regardless of the degree of fitness or pre-amputation activity. The fitness program should begin with conditioning exercises. As strength and flexibility are developed, sports activities may be combined with the exercises. Over time, athletic ability will increase and goals may be broadened.

Without reasonable precaution, physical exercise and sports can pose a risk of injury, and overexertion may result in cardiovascular complications. People with a lower limb amputation must learn to compensate for impaired balance and mobility; their risk of injury is far greater than that of nondisabled individuals. A sound limb will usually become stronger through regular physical activity. It must be carefully protected from injury because dysfunction will result if it is unable to sustain weightbearing. Learning to use protective equipment, such as knee braces, and learning to avoid unnecessary risk are integral parts of a physical conditioning program.

A person who is physically fit has more energy, and this contributes to improved performance in other aspects of life. The best surgery, technology, therapy, and prosthesis cannot provide this energy without the motivation of the individual to develop new physical strength. This book is intended to help by stimulating motivation and action.

Chapter 2, The Rehabilitation Process, addresses the purpose and scope of this book as they relate to the rehabilitation process. Chapter 3, Components of Physical Conditioning, briefly defines and discusses the main components of physical conditioning: cardiovascular endurance; flexibility; muscular strength and endurance; and skill development. Part Two presents a selection of exercises to develop flexibility and muscular strength and endurance that can be adapted to various skill levels and conditioning needs of people with lower limb amputation. Part Three describes the application of good physical conditioning to skill acquisition in several sports that promote cardiovascular fitness and can be enjoyed throughout a lifetime. Safety precautions and assistive modifications are described for the activities presented in Parts Two and Three.

Along with good physical fitness, diet and nutrition are important factors in total health. This book concentrates on conditioning, however, and does not include information on diet and nutrition.

2

THE REHABILITATION PROCESS

THE INDIVIDUAL WITH AMPUTATION

The development of temporary prosthetic function has been one of the most significant advances in rehabilitation over the past two decades. Automated fabrication using computer-aided design/computer-aided manufacturing (CAD/CAM) promises to provide inexpensive, functional early-fit prostheses, as well as improved definitive limbs, at an acceptable cost. These new prostheses are designed to be lightweight, energy-storing, and adjustable at the socket interface in order to maintain socket fit as the residual limb matures. Their early and routine use leading up to definitive prosthetic fit is becoming standard accepted practice.

When the first temporary prosthesis is fitted, physical activities are gradually begun. A temporary prosthesis is usually started after the wound is healed and a degree of residual limb shrinkage has occurred. Timing is important. If a prosthesis is made before the major portion of the shrinkage occurs, a new limb will be required within a few weeks. During the first year after surgery, the temporary prosthesis will require regular adjustments and often several replacements as the size and shape of the residual limb become stable.

Physical conditioning may begin without wearing the prosthesis. Stretching and flexibility exercises, Nautilus™ or similar seated weight-training machines, and sports such as swimming, stationary bicycling or rowing, water aerobics, and crutch soccer may be performed without a prosthesis. As the residual limb stabilizes in size, more time can be spent in activities that require wearing the prosthesis.

The prosthesis should be viewed as an assistive device. Prostheses permit better performance, fit more comfortably, are lighter in weight, and look more realistic than ever before, but they do not replace a real leg in function. They do not automatically adjust to changes in weight or other causes of increased interface pressure.

Many people who are getting their first prosthesis tend to start doing too much too quickly. This can often lead to pain and irritation of the residual limb or other parts of the body that are compensating for the amputation. It can result in the temporary inability to wear the prosthesis. Such setbacks are discouraging. The entire body, as well as the residual limb, needs to adjust to the new stresses. Until the individual is fully adapted to walking comfortably with the prosthesis, movements that produce increased stress (such as running) should not be attempted.

Most healthy people with a unilateral lower limb amputation will be able to run or jog as they wish, and some may become successful competitors in sports events that require endurance running. In more limited circumstances, these activities are possible for those with bilateral amputations. For individuals who are subject to residual limb soft-tissue breakdown as a result of scarring—or for other reasons—as well as those with high-level amputations, it may be better to choose activities that do not require the use of a prosthesis.

ELAINE NAISMITH

Elaine Naismith continues her work as a flight attendant and enjoys playing tennis.

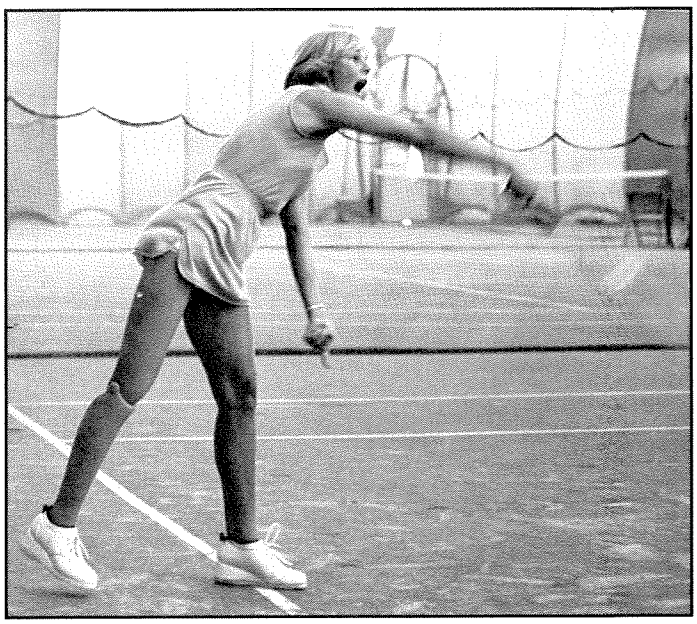
Exercise is effective only if it is done on a regular basis; sporadic exercise is not much better than no exercise at all. Ideally, one should start with an activity participated in prior to the amputation. Most people will be able to get back into shape. Many individuals who were not physically active before losing a limb have improved their physical condition. They have understood that being fit provides them with the energy they need to overcome their disability.

Considerations for Older People

Most amputations performed today result from peripheral vascular disease, diabetes, and related conditions; a majority involve the lower limb and are related to the general health of the individual. Many of the individuals who require amputation are 60 years of age or older. This population poses a new challenge for health care and rehabilitation professionals. Accidents and other trauma-related causes account for a modest percentage, as do tumors. A small segment of the amputee population results from congenital limb loss and congenital limb deficiencies, while war-related and natural disaster amputations remain a factor in many areas of the world.

Physical fitness for the older adult is important. Muscles lose their elasticity with passing years. Changes in the arteries and the pumping action of the heart may cause a decrease in blood delivery to exercising muscles. Moderate physical activity can slow the aging process and provide the benefits of better health.

In beginning an exercise program, each aspect of muscle conditioning must be gradual and carefully monitored because, for some older individuals, even a gentle exercise routine can involve risk. As strength is developed, walking and light jogging can become part of the routine. Consistency in performing the exercise program is especially important. The aging process is accompanied by diminishing muscle flexibility, strength, and endurance. A consistent



ELAINE NAISMITH

Elaine Naismith added lifts to tennis shoes so that the same prosthetic foot can be used with dress shoes.

physical fitness program has shown to slow these aging effects.

Considerations for Children

In children with congenital limb deficiencies, residual lower limbs often will allow partial or full end weightbearing. This is particularly true when no surgery has been necessary and the soft tissues at the distal end of the residual limb possess weightbearing capacity. Prosthetic components available to children and small adolescents are limited compared with the choices available to the adult population. Prosthetic fittings for children must be maintained and checked on a regular basis to accommodate for growth.

THE REHABILITATION TEAM

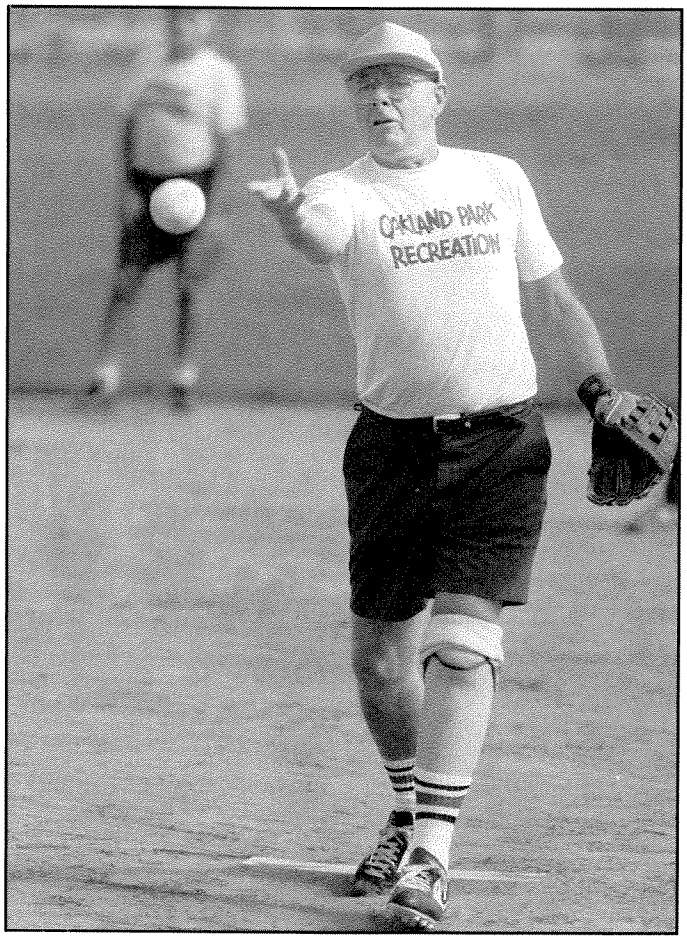
Rehabilitation of a person who has had an amputation requires a special care-giver team. No single health care discipline can provide all of the services needed. The patient is an active participant in each step of the recovery process. Along with the patient, the primary members of the rehabilitation team are the surgeon, physical therapist, nurse, and prosthetist.

The initial purpose of this team is to monitor the healing process in preparation for fitting a prosthesis. Physical therapy begins in the hospital; a program for physical conditioning is usually discussed later in the rehabilitation process.

Preoperative Considerations

When the amputation is elective, the physical part of the recovery process can actually begin prior to surgery. It consists of stretches to improve range of motion of joints and weight resistance exercises to increase strength and endurance. Rehabilitation goals may be discussed at that time to help the individual understand what he or she can expect in the way of return of function.

A visit by one whose circumstances compare to those of the patient awaiting amputation is one of the best forms of preoperative counseling. An elderly person may view the upcoming amputation as the end of life: immobilized, confined to a wheelchair or bed, and totally dependent on others for care. A visit from an active person of the same age who has had an amputation can often overcome these fears. A young person is almost always responsive to a visit from a young amputee who has recently been snow skiing or bicycling or playing tennis.

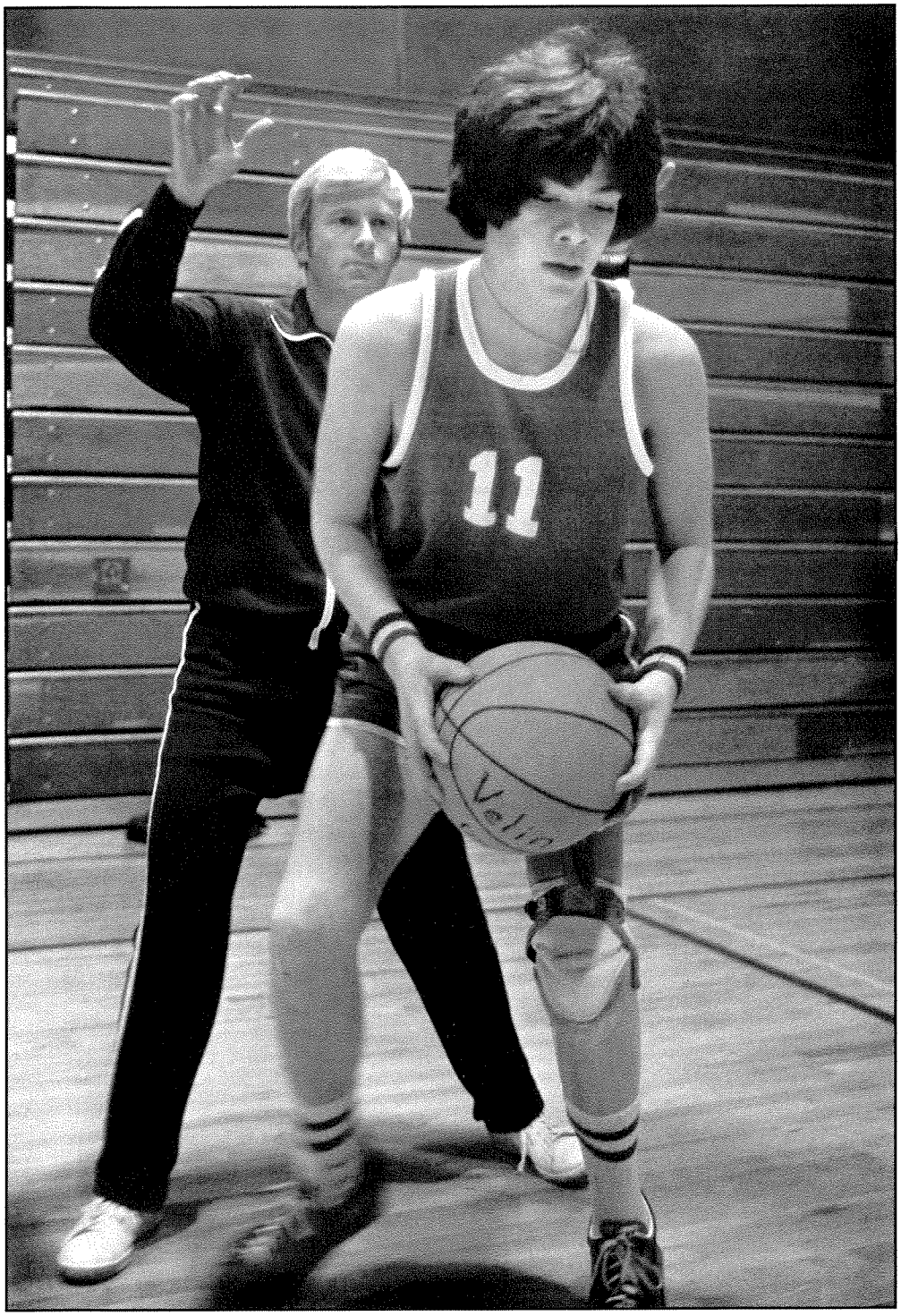


KEITH HADLEY/NEWS-SENTINEL
World War II veteran Ed McCausland plays recreational softball on a nondisabled league.

Apprehension about pain is a serious concern. The patient should know that pain will be properly controlled following surgery and that adequate medication can even allow for early movement and physical activity.

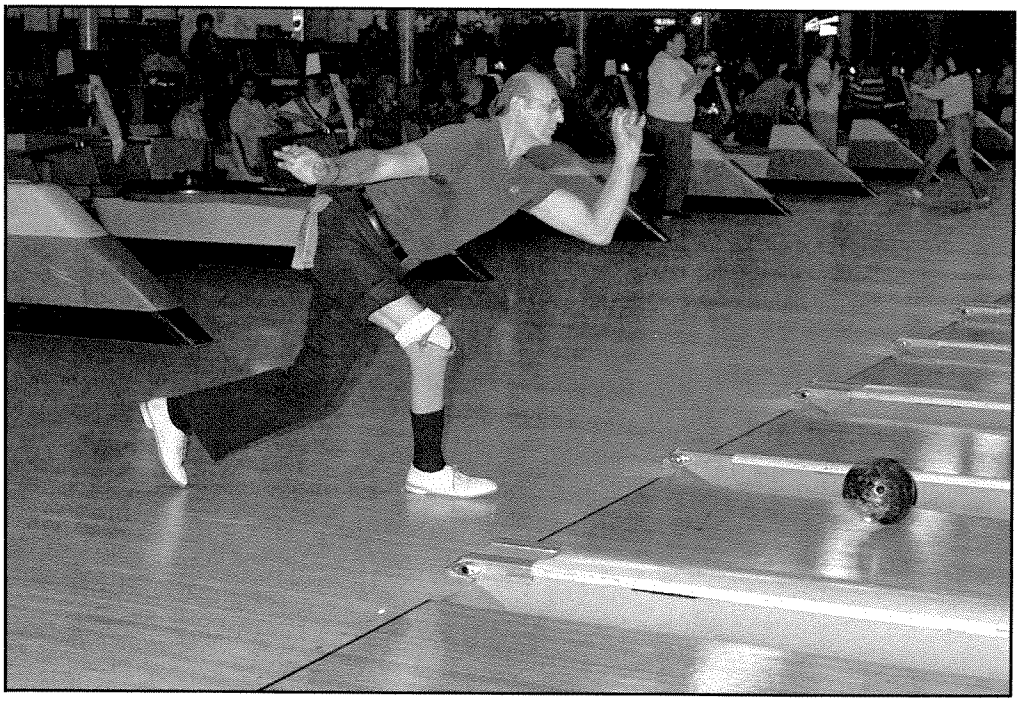
Surgical Procedures

The surgeon who performs the amputation is responsible for selecting the level of limb removal and for reconstructing the residual soft tissues and bone. Technical details of amputation surgery (conservation of length, muscle stabilization, treatment of bone, nerves, blood vessels, and subcutaneous tissues) are critical to residual limb function. The muscles and remaining joints of the residual limb act to control the prosthesis. Muscle action through the tendon and aponeurosis attachments to bone also



PETE LIDDELL/SEATTLE TIMES

Mike Day practices basketball moves with coaching from his high school athletic director, Rich Gustafson.



JOHN WOODMANSEE/DVAMC, SEATTLE, WA

Joe Demkovic, a World War II veteran, bowls three times a week.

provide a sense of proprioception (position and movement) and are very important to prosthetic control.

The degree and extent to which an individual with an amputation can engage in normal physical activities and sports will often be determined during surgery. Modern surgical techniques are described in medical textbooks, and new applications can be found in state-of-the-art monographs.

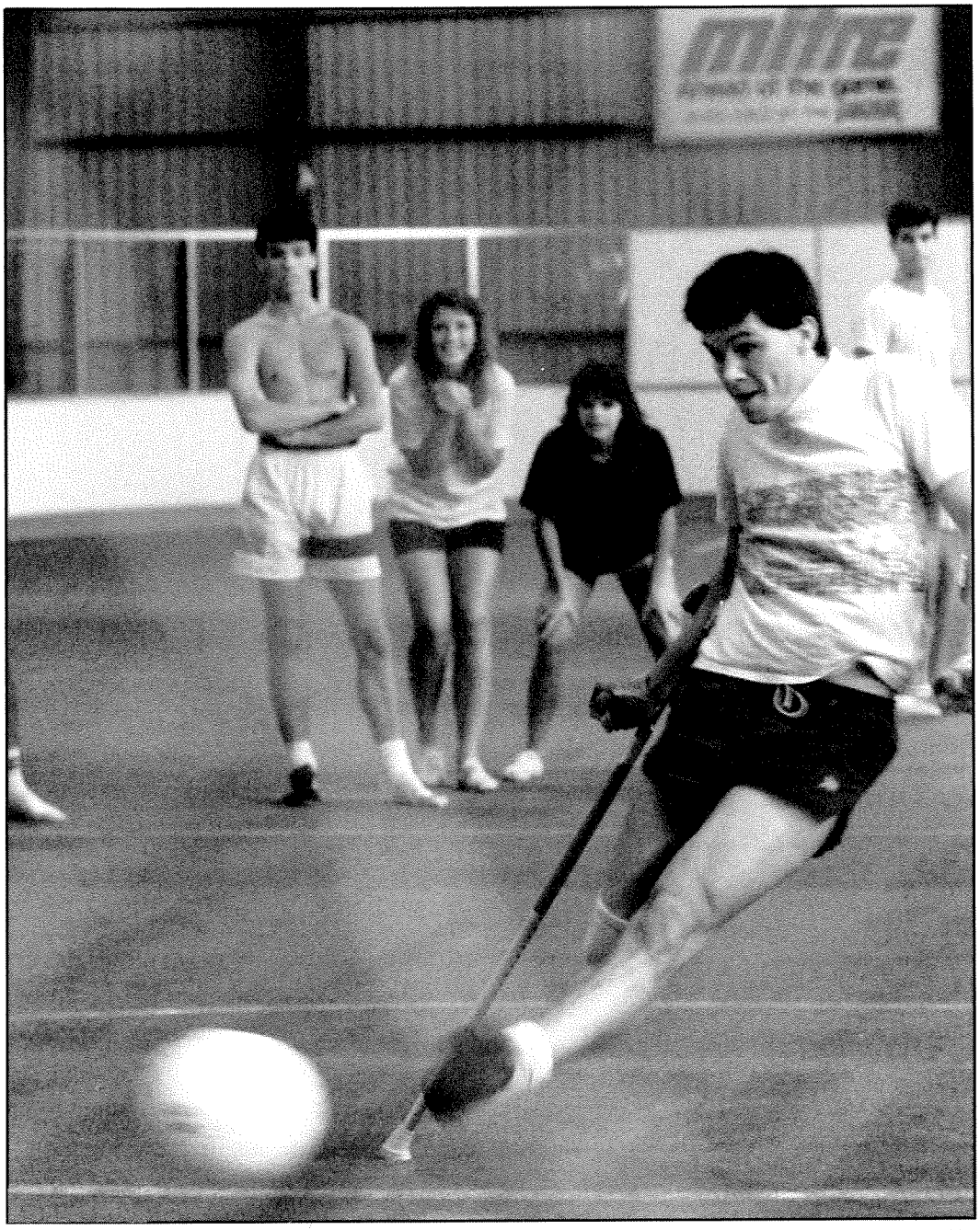
Postoperative Rehabilitation

Emphasis upon immediate and progressive physical movement and prosthetic applications has accelerated the rehabilitation period for people of all ages. Two goals direct rehabilitation management. The first is to obtain uneventful wound healing. The second is to begin the rehabilitation process immediately.

These objectives are best accomplished by rigid dressing management which provides support, protection and rest for the tissues, a clean wound-healing environment, and pain control. Because of these features, rigid dressings allow the patient to move about comfortably early in the postoperative period. The rigid dressing actually forms a receptacle which can serve as a socket for an immediate or early postoperative prosthesis. Limited weight-bearing using crutches or a walker may begin as soon after surgery as the patient is able, with moderated increases in the amount of weight as wound healing progresses. Full weightbearing is not allowed until the use of a temporary socket can be tolerated.

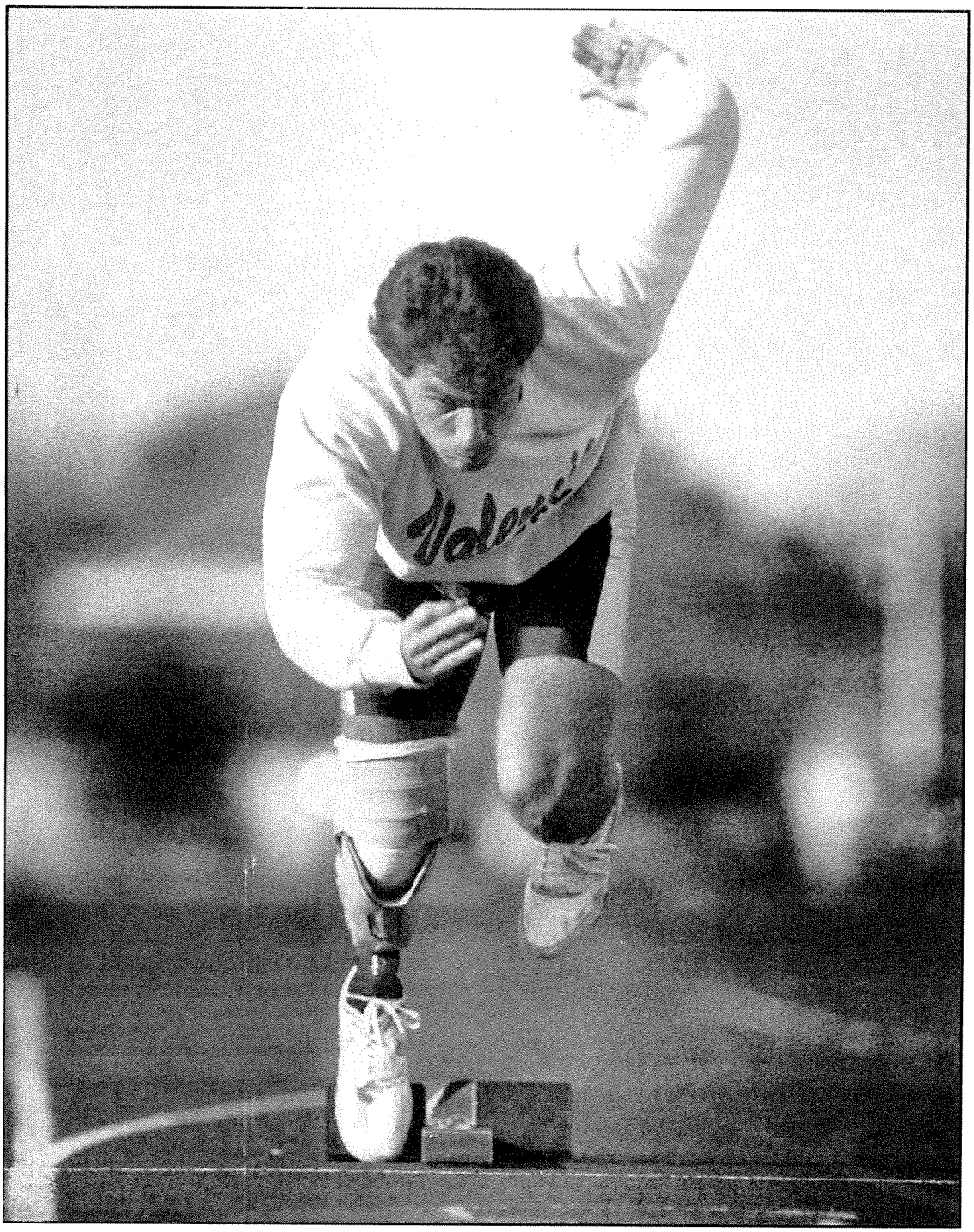
In other postoperative methods, elastic bandages (e.g., Ace® Brand™ Athletic Bandage) or an elastic stockinette are used to wrap the residual limb to prepare it for prosthetic fitting. The pylon and foot, which can be attached to a plaster cast, allow for early limited weightbearing. Soft dressings are easy to apply, but are not usually as effective as a rigid dressing.

Progressive rehabilitation is the key to recovery. A carefully planned and well-timed recovery process that encourages optimum physical activity is basic to regaining a sense of "wholeness." The rehabilitation team will recommend community organizations that are involved in physical fitness and provide support services, such as National Handicapped Sports (NHS), which offers specialized instruction in adapting physical activities to individual disabilities.



STEVE WILBER, SEATTLE, WA

Kevin Wilson goes for the ball in a game of crutch soccer.



J. CONRAD WILLIAMS, JR./NEWSDAY

Recent advancements in prosthetic technology have made active physical pursuits, such as competitive running, possible and rewarding for many people with lower limb amputation. Pictured is Dennis Oehler, who set a world record of 11.73 seconds in the 100 meter dash event for BK amputee athletes at the 1988 Olympics in Seoul, Korea.

3

COMPONENTS OF PHYSICAL CONDITIONING

The main components of physical conditioning are cardiovascular endurance, flexibility, muscular strength and endurance, and skill development. The cardiovascular system is conditioned most effectively by active exercise such as running, swimming, or bicycling, and to a lesser degree, by weight resistance exercise and arm-cranking. Controlled passive exercise using machines, temperature changes, medication, or diets cannot replace active exercise. Flexibility, which also can be improved by weight training, is best achieved through stretching exercises that increase the body's range of motion. Muscular strength and endurance are developed through weight resistance exercise and, to a lesser degree, through sports activities.

A great deal is known about muscle physiology. Recent studies and technological developments have changed training techniques to verify certain practices which, in the past, had been based on empiric observations. The sports therapist, physiologist, trainer, and physical educator can adapt their methodology based on this new scientific information.

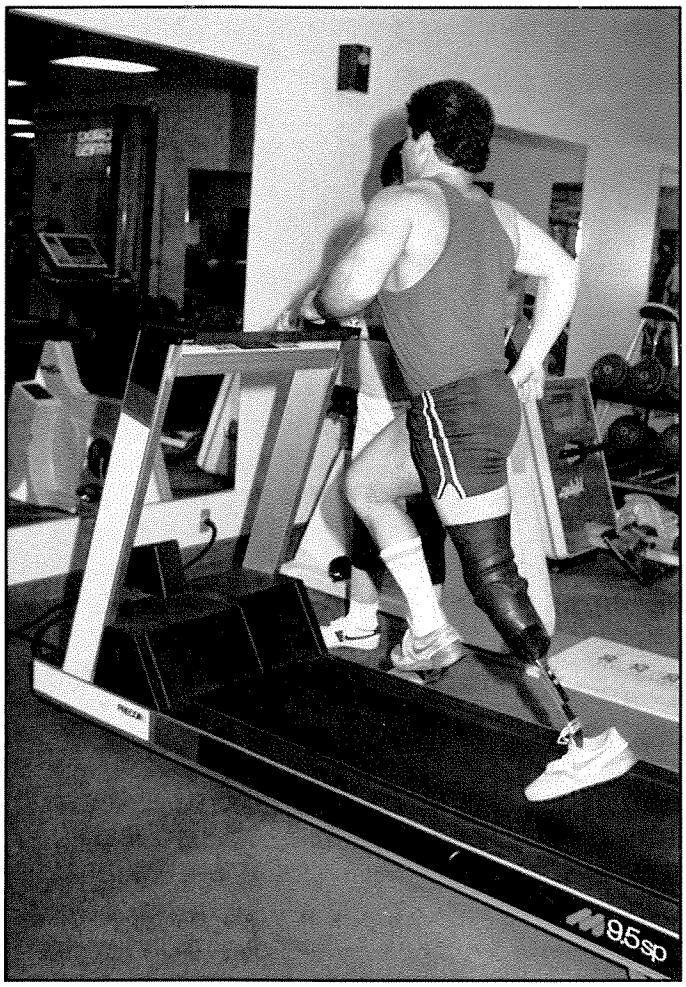
Computerized equipment accurately measures and monitors cardiorespiratory function at rest and while exercising. Many of the advances in the techniques of training and physical conditioning have been stimulated by organized sports competition. Biomechanical video analysis is useful to coaches who are trying to improve team performance. Football players participate in aerobic dance classes; weightlifting for strength and endurance is used by athletes in every competitive sport to improve performance.

A person with a lower limb amputation can exercise for fitness and train for sports in virtually the same ways as a nondisabled person. There may be some modifications to the workout routine depending on the level of amputation and the accessibility of special facilities.

CARDIOVASCULAR ENDURANCE

The word "aerobic" refers to a state of physical well-being in which the heart and lungs combine to provide life-giving oxygen and nutrition to the body's cells. The heart, lungs, and circulatory system transport the gases and nutrients which reach every body cell. In these cells, the complicated process of energy conversion takes place and waste products are discarded. We breathe and our hearts beat continuously many trillions of times during the course of our lives. The more efficient our system, the greater our capacity to perform mechanically.

The efficiency of the cardiovascular system is improved by the things that improve general health. These include diet, weight control, appropriate rest, and exercise. Several changes take place in the cardiovascular system once aerobic conditioning begins. For example, stroke volume will increase after regular intervals of physical conditioning. This means that every time the heart beats, more blood is made available to the circulatory system. The heart



JOHN WOODMANSEE/DVAMC, SEATTLE, WA

Treadmill Running Training on the treadmill is a form of steady state exercise. The speed of the treadmill can be varied to achieve individual aerobic fitness levels. The treadmill provides an opportunity for a person with amputation to run in a controlled environment on a regular basis.

will be able to beat fewer times to accomplish work at the same rate. The amount of work accomplished is dependent upon the amount of time expended. Both at rest and against a given load, the heart rate is lower as one's stroke volume increases. Another important effect of conditioning is that more oxygen can be taken from the hemoglobin (the iron-containing pigment in the red-blood cell that carries oxygen from the lungs to the tissues). Tissue oxygenation is also improved by increasing the number and density of capillaries in the muscles being worked. Even in sedentary individuals, these aerobic effects can begin to be realized after as little as 3 weeks of regular aerobic exercise.

Dr. Kenneth Cooper in his book, *The Aerobics Program for Total Well-Being,* defines aerobic exercises as activities "that demand large quantities of oxygen for prolonged periods and ultimately force the body to improve those systems responsible for the transportation of oxygen. In other words, the exercise is being performed with the body in a 'steady state'."[1] The healthy body always maintains homeostasis, a balance of its physiological systems. However, the level of energy expenditure needed to maintain homeostasis is quite different if one is sleeping or performing an active aerobic exercise. For aerobic conditioning, one must perform some kind of active training that brings oxygen into the muscular system (e.g., running, slow jogging, bicycling, swimming, cross-country skiing, rowing, playing basketball) for sustained periods of time. The opposite of this is anaerobic exercise during which the energy is provided without utilization of inspired oxygen (i.e., exercise that is limited to short bursts of vigorous activity, such as weight lifting).

To improve cardiovascular endurance, one should continually try to increase the length of time and level of energy expenditure so that the cardiovascular system can respond to the increased loads. Only by increasing the intensity, frequency, and duration of the exercise can the individual progress to higher levels of fitness. This is known as the "overload" principle because it requires the exercise intensity to be near the maximum when applied to either aerobic or anaerobic training programs.[2]

For example, there are a variety of training programs for running long- and short-distance races. Each varies with the length of the race. Many of the techniques involved can be attributed to refinement of training methods used by coaches and athletes throughout the years. Anaerobic/sprint capacities can be increased and aerobic/endurance performance can be improved. Interval training is a system that involves several bouts of hard work alternating with periods of lighter work or rest, thereby allowing for maximum intensity during the work intervals. "Manipulation of the rate and distance of the work interval, the number of repetitions, and the time and type of relief interval provides training programs that can meet the needs of many athletes and non-athletes."[3]

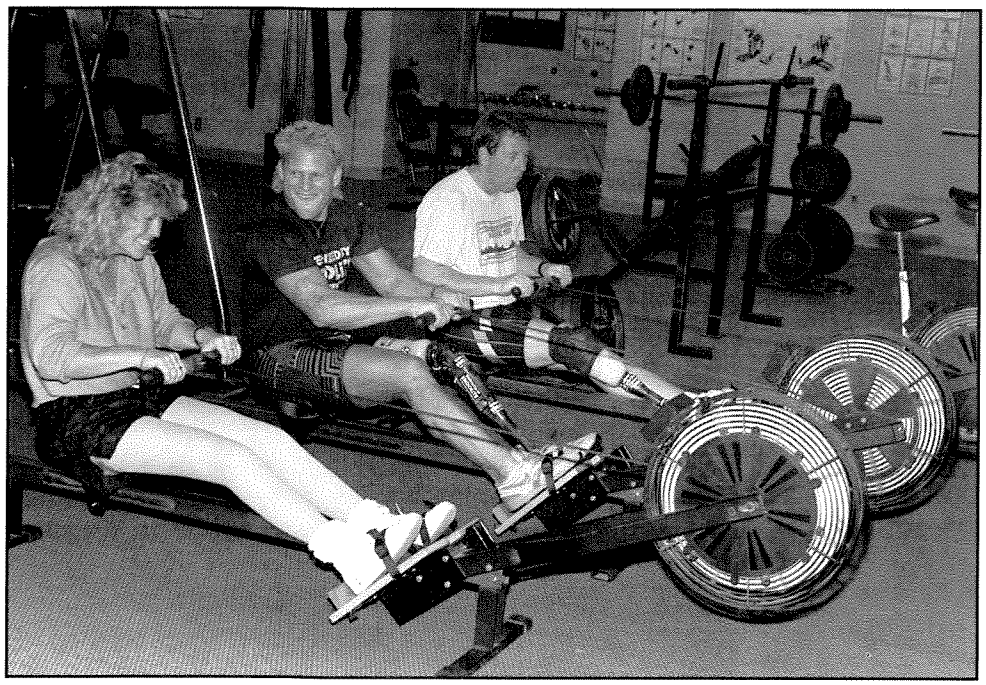
Research results have demonstrated the benefits of aerobic conditioning for people with lower limb loss. In one study, 10 such people participated in a

15-week aerobic conditioning program to determine whether it would improve cardiovascular fitness and reduce the effort required for walking.[4] Two of the subjects had bilateral amputations, three had above-knee (AK) amputation, four had below-knee (BK) amputation, and one had a partial foot amputation. All had been sedentary prior to the program; none had participated in any form of physical exercise or sport for several years. The average age of the subjects was 39. The program consisted of regular weekly exercise on a Schwinn® Air-Dyne Ergometer. Subjects exercised at 60 to 80 percent of their estimated maximum heart rate. Tests of maximum exercise on the ergometer and walking on a treadmill were conducted before and after training. Results showed a 25 percent increase in the maximum capacity for exercise on the ergometer and notably lower values for heart rate and oxygen consumption during treadmill walking at various inclines.

In another study demonstrating the positive effects of aerobic conditioning in the early stages of rehabilitation, subjects were middle-aged to elderly and had unilateral AK or BK amputations.[5] Following 14 weeks of regular exercise on a Schwinn Air-Dyne Ergometer that was modified for combined lateral arm/unilateral leg training while seated in their wheelchairs, all subjects showed improved cardiovascular response. Moreover, preliminary findings suggest that a combined arm-leg ergometer may provide improved function in wheelchair propulsion and prosthetic ambulation as well as aerobic conditioning and endurance training.

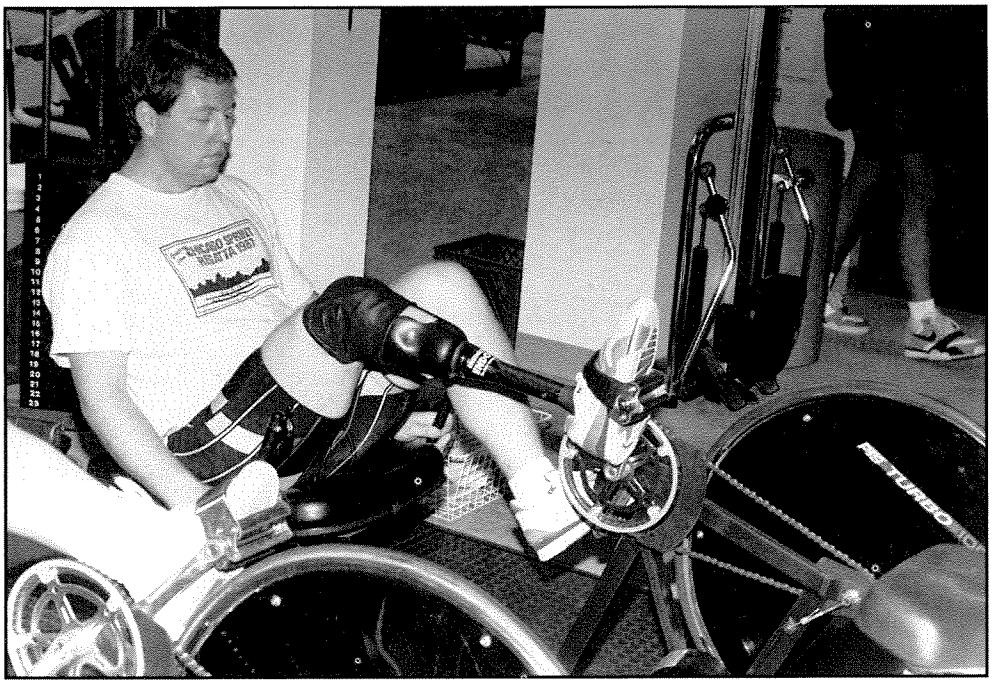
FLEXIBILITY

Flexibility is the ability to move without restriction during a normal range of movement: it is the quality of being bent without breaking. It is measured by the range of motion present through the connective tissues of ligaments and tendons that surround the joints between the bones and other parts of the body. Natural flexibility decreases with age. A child's body is flexible because the skeleton contains more cartilage, the bones are soft, and the muscles, ligaments, and tendons are more elastic. The loss of flexibility from childhood through adulthood cannot be avoided. However, it can be delayed by regularly performed exercises that stretch and improve the range of muscle and joint movement. Adults who maintain their flexibility through stretching exercises feel better, have more energy for everyday activities, and are less susceptible to injuries during sports participation. Stretching exer-



JOHN WOODMANSEE/DVAMC, SEATTLE, WA

Rowing While we normally think of rowing a boat on a lake or river, the benefits of this exercise are accessible on stationary rowing machines available for in-home use or in the gym. These machines and computerized rowing machines can provide good aerobic conditioning.



JOHN WOODMANSEE/DVAMC, SEATTLE, WA

Stationary Bicycle Riding The stationary bicycle can be used at home as well as in the gym. Interval training can be done manually or on computer-driven exercise bicycles.

cises done on a regular basis will help people who suffer from chronic muscle "stiffness" to limber up and maintain a stretched-out feeling.

Stretching is a simple and painless method of preparing for vigorous physical activity without causing undue strain upon the body. Anyone can learn to stretch and regain some of the flexibility lost through the aging process. Athletic ability, past or present, is not necessary. However, before beginning stretching exercises, it is important that the potential exerciser carefully assess his or her physical condition, health, and capacity for muscle tension and flexibility, since stretching exercises should be individually tailored. A physician should be consulted and advised about any existing physical problems, recent surgery (particularly pertaining to the joints and muscles), or prolonged inactivity.

Stretching exercises must be performed correctly with the exerciser focusing on the range of motion of a particular muscle group and stretching only far enough to feel tension—not pain. Those who have been involved in other forms of conditioning have been told, "No pain, no gain." This philosophy does not hold true for stretching because muscles need to be relaxed in order to stretch further. People who stretch incorrectly have a tendency to bounce up and down until the exercise creates pain, which should be the signal to stop.

Muscle strain activates the protective stretch mechanism called the "stretch reflex." Each time muscle fibers are stretched too far by either bouncing or over-stretching, a nerve reflex sends a signal to the muscle to contract. This involuntary contraction keeps the muscle from being injured or over-stretched. When over-stretched, muscles actually tighten and the body's natural defense mechanism protects them from injury. However, repeated incorrect methods of stretching can cause not only pain, but microscopic tearing of the muscle fibers. This tearing eventually causes the formation of scar tissue which gradually results in the loss of elasticity and flexibility.

MUSCULAR STRENGTH AND ENDURANCE

Physical strength is achieved through muscle development. Muscular strength is defined as the force or tension of a muscle group which can be exerted against a resistance in one maximal effort. Muscle strength and increase in muscle size are acquired by muscles working against a resistant force which is gradually increased as the muscles become stronger.

A strength conditioning program usually consists of progressively resistive weight exercises. The

exercises can concentrate on specific goals such as building muscle bulk, power weightlifting, muscle definition, muscle tone, endurance for a specific sport, or skills. The muscle groups of the body can be isolated and trained. Nutrition, amount of rest, and genetics also play a part in achieving these goals.

Endurance is acquired by repetitive exercise against a constant level of resistance. Light resistance exercises repeated many times produces endurance. However, muscle exercise for endurance affects muscle bulk only slightly and does not increase muscle strength. For that reason, it is necessary to combine endurance and strength exercises in a coordinated program.

Increases in strength and endurance are accompanied by physiological changes, that is, increased muscle size (hypertrophy), biochemical alterations, and adaptations in the nervous system. A muscle shortens while lifting, and lengthens while lowering, a constant load. The tension developed over the range of motion depends upon the length of the muscle, the angle of the pull of the muscle on the skeleton, and the speed of the shortening.

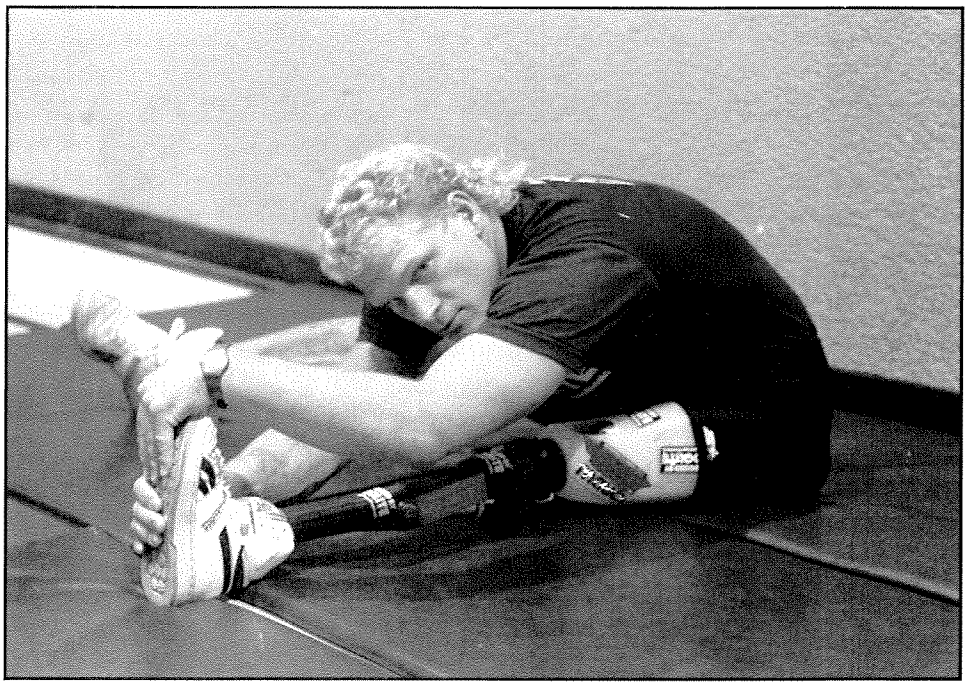
Muscular strength and endurance are developed by practicing the overload principle. Strength, endurance, and hypertrophy of a muscle will increase only when that muscle performs for given periods of time at its maximal capacity to work against resistance and loads that are above those normally encountered.

As one develops strength and endurance, participation in aerobic and sports activities becomes easier. Strength gains can be specifically oriented toward sports performance by focusing on exercises that simulate movement patterns used in the skill of a particular sport. Most exercise physiologists feel that it takes from 6 to 12 weeks of progressive, organized, muscle-resistance exercise to build up an optimum level of strength for the performance of many competitive sports activities. For outdoor seasonal sports, the program can be combined for maintenance-conditioning during the sport season and for strength-conditioning during the off-season.

Muscle Soreness

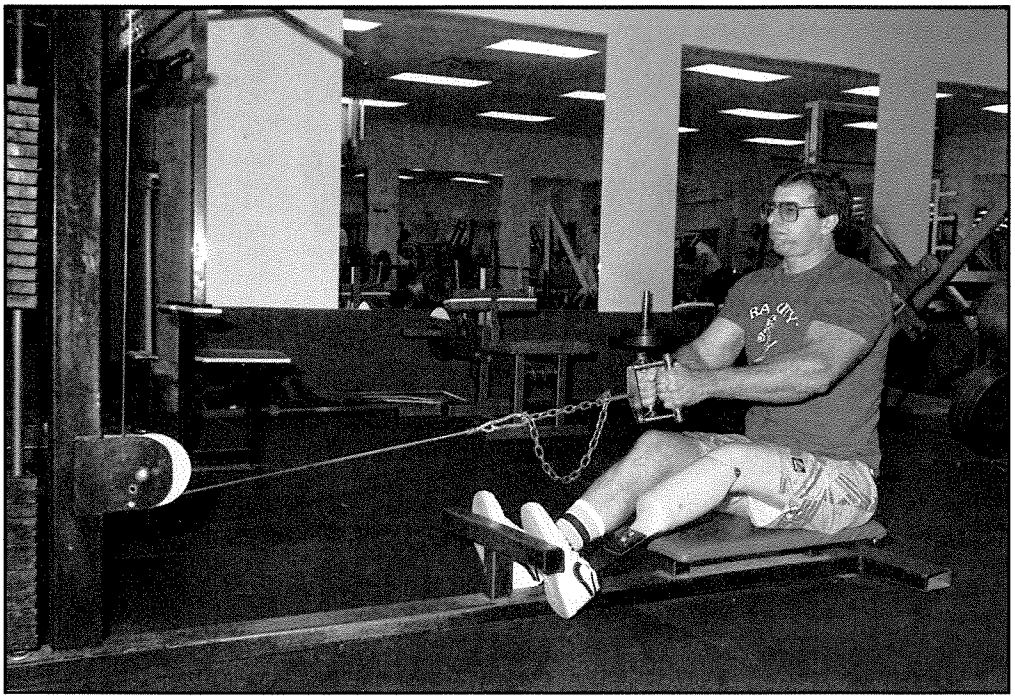
Muscle soreness is common to beginners in a strengthening program. Two types of soreness can result from muscle strain: acute and delayed.

Acute muscle soreness is often caused by inadequate blood flow. Tension created in a muscular contraction occludes blood flow to the muscles being worked thereby causing ischemia. Metabolic



Stretching Exercise
Greg Mannino works to touch his head to his knee.

JOHN WOODMANSEE/DVAMC, SEATTLE, WA



JOHN WOODMANSEE/DVAMC, SEATTLE, WA

Strength Conditioning Pulling against resistance and lifting weights strengthens the muscles of the arms and upper back.

waste products like potassium and lactic acid cannot be removed from the blood because of the build-up of ischemia. This build-up can actually stimulate the pain receptors in the muscles, causing soreness. The pain or soreness will subside when the exercise producing the contraction of the muscles is reduced or completely stopped. The blood can then flow in a normal manner, creating an environment for the removal of lactic acid and potassium. The complete removal of these waste products can take many hours, but a majority are removed within the first 15-60 seconds after the contraction of the muscle has ceased. For this reason, a 30- to 60-second rest period between each set of weightlifting exercise is always recommended to allow any soreness to subside.

Delayed muscle soreness is usually caused by a disruption of the connective tissues. This form of soreness is commonly noticed between 24-48 hours after exercising. Several theories exist regarding the cause of delayed muscle soreness and some observations have been made pertaining to prevention. For example, controlled stretching before and after an activity has been found to be helpful. Stretching is also effective in soothing existing muscle soreness. A carefully graduated exercise program can help prevent delayed muscle soreness.

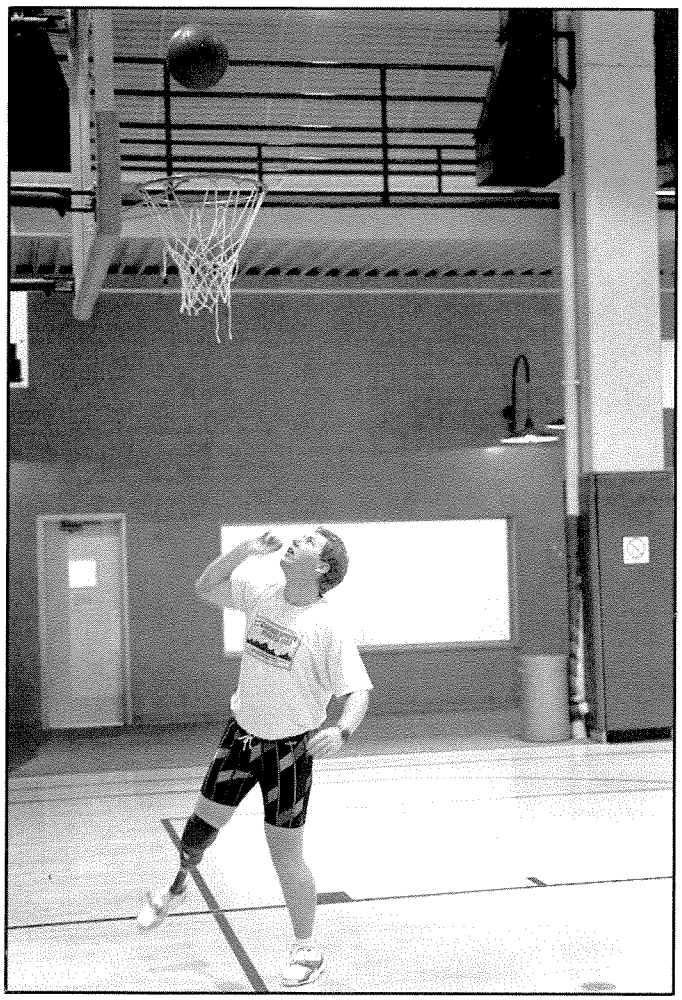
SKILL DEVELOPMENT

Being skilled in sports implies the ability to excel. Time, distance, and accuracy objectively measure skillful performance. Competition is also a measure of skill; as are coordination, balance, and speed.

Skill also can be expressed in terms of grace, beauty, and aesthetics. The ballet dancer, equestrian, basketball player, and gymnast perform with varying degrees of artistry. While these qualities are not easy to measure objectively, they represent true forms of physical and artistic skill. Thus, many athletic skills are both physical and artistic.

Skillful physical performance is also the result of neuromuscular coordination. Finely-tuned coordination can be both inborn and acquired. Certain voluntary and involuntary movements can be described as being clumsy, awkward, and poorly coordinated. On the other hand, trained and coordinated movements are usually graceful and precise. Young children playing active physical games during a school recess exhibit a wide variety of inborn neuromuscular coordination.

Acquired skills are the result of physical conditioning, fitness, and practice. No matter how much natural physical ability a person possesses, proper



DALE TILLY/DVAMC, SEATTLE, WA

Skill at Work Basketball combines skill and concentration with enjoyable exercise.

coaching and training will develop skill. Successful athletes continually improve their skills through the application of more refined techniques, and not necessarily by building greater strength and endurance. Precision sports, such as golf, constantly exemplify the need for perfecting technique.

For the person with lower limb loss, there are always compensations to be made when participating in physical activities. However, the compensations can be reduced by effective prosthetic substitution and/or adaptations. It also becomes natural for such individuals to enhance their performance through creative use of other parts of their body. Participating in activities wherein the physical loss of a limb can be successfully compensated for will result in maximum enjoyment and potential for skill development.

NOTES

1. K.H. Cooper, *The Aerobics Program for Total Well-Being.* New York: Bantam Books, 1982, p. 112.

2. E.L. Fox and D.K. Mathew, *Physiological Basis of Physical Education and Athletes.* Philadelphia: CBS College Publishing, 1981, pp. 273-291.

3. *Ibid.,* p. 162.

4. K.H. Pitetti, P.G. Snell, J. Stray-Gundersen, and FA Gottschalk, "Aerobic Training Exercises for Individuals Who Had Amputation of the Lower Limb." *Journal of Bone and Joint Surgery,* 69-A(6), 1987, pp. 914-921.

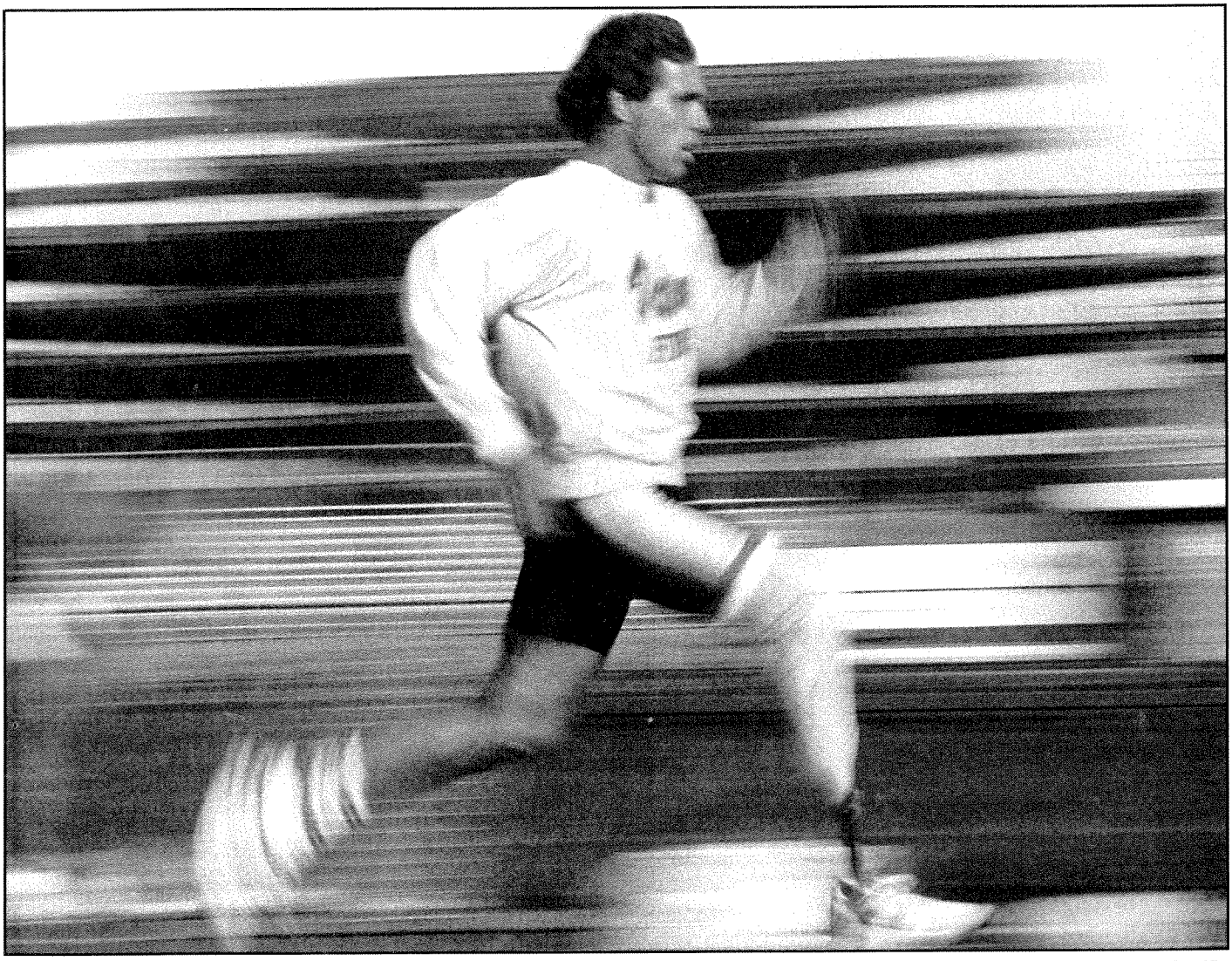
5. A.G. Bostom, E. Bates, N. Mazzarella, E. Block, and J. Adler, "Ergometer Modification for Combined Arm-Leg Use by Lower Extremity Amputees in Cardiovascular Testing and Training." *Archives of Physical Medicine and Rehabilitation,* 68(April), 1987, pp. 244-247.

Greg Mannino demonstrates a muscle strengthening exercise.

All photographs in Chapters 5 through 12 (unless otherwise credited) were taken by Dale Tilly or John Woodmansee of the Medical Media Service, Department of Veterans Affairs Medical Center, Seattle, WA.

PART TWO

CONDITIONING EXERCISES



NEWSDAY/J. CONRAD WILLIAMS, JR.

4

INTRODUCTION

The physical conditioning routines included in this book offer possibilities for individuals with lower limb amputation. We begin with calisthenics and stretches to improve flexibility and range of motion, followed by exercises to develop strength and muscular endurance in specific muscle groups for the arms, shoulders, legs, abdomen, chest, and back.

The conditioning exercises are performed with equipment such as Nautilus, available in most health clubs. An individual with a lower limb amputation can usually work the same muscle groups on the same equipment as can a nondisabled person, but not always in the same manner.

Special adaptations or modifications that will help to make these exercises safe and effective are noted in the corresponding descriptions. In many cases, the prosthesis alone provides the necessary support for the movements required. Exercises that will help strengthen the muscles of the residual limb are also indicated in the descriptions. Many of the exercises in Part Two are performed while the participant is seated; this allows the participant to concentrate on the exercises and weights without having to worry about maintaining balance while standing.

Variations for some of the exercises depend on the level of amputation. Range of motion and balance may not be the same for a person with an AK amputation as they are for someone with a BK amputation. Besides level of amputation, other variables include the surgical history, previous training, and type of prosthesis used. The prosthetist, therapist, and exercise instructor can help identify the best opportunities for exercise based on these variables.

The exercises illustrated in this book are performed by athletes who train on a regular basis. All are in excellent physical condition and demonstrate exercises that require a range of skill and practice. Beginners should not attempt to perform any of the exercises without first consulting a physician.

CAUTION

People with back injury should avoid lifting heavy weights in their exercise programs. To develop strength and endurance, they should do more repetitions with light weights rather than increasing the resistance.

Any exercise has the potential to cause injury to the back, whether or not one has had previous back injury. In particular, this would include sit-ups and other exercises involving hyperextension of the back, as noted in Chapter 10, Abdominals. Leg exercises requiring special caution, as noted in their descriptions, are squats and dead lift. Exercises that make the lower back vulnerable to injury are noted in Chapter 12, Back Exercises.

It is important that persons entering an aerobic exercise program obtain medical clearance prior to outlining the exercise regime. This precaution is repeatedly stressed throughout this text. Individuals

who have hypertension, for example, are particularly at risk in weight training as well as aerobic programs. Coronary artery insufficiency is another example of a risk factor in undertaking an aerobic exercise program. These risks apply for the nonamputee as well as the amputee. Medical clearance at all ages is absolutely necessary.

MONITORING THE INTENSITY OF AEROBIC EXERCISE

In order for exercise to promote optimum aerobic benefit, it must cause the heart to work at an accelerated rate and in a steady state for a period of time. Monitoring the heart rate during exercise is the best way to determine whether the routine is providing the desired aerobic benefits while ensuring that the heart is not being overworked. It is done by establishing a target heart rate and monitoring the beats per minute immediately after the conditioning exercise routine is completed. The goal is to maintain the target heart rate throughout the exercise period (warm-up and cool-down are not part of this period).

Establishing a Target Heart Rate Range

A target heart rate range for exercise can be predicted as follows: 1) a person's age in years is subtracted from 220 to give the maximum predicted heart rate (beats per minute); 2) the range is determined by figuring the percentage of the maximum rate that the person must work during exercise in order to achieve his/her target goal (70 to 85 percent is the range which is considered to be the most effective for receiving adequate aerobic benefits). For example, a 35-year-old person will have a maximum predicted heart rate of 185 (220 minus 35). If this person begins an exercise regimen with a goal of maintaining a 78 percent target heart rate, his/her target will be 144 heartbeats per minute (0.78 times 185).

Exercise at the targeted rate should last from 15 to 30 minutes. During this time the heart rate is monitored. Immediately after the routine is completed, the pulse should be taken to determine the heart rate. Most people take a 10-second, rather than a full minute, pulse count. The 10-second count is then multiplied by 6. Any irregularity in heart rate, including rapid variations, calls for

SAMPLE CIRCUIT TRAINING

SIT UPS

BENCH PRESS

LATERAL PULL DOWN

LEG PRESS

SIT UPS

MILITARY PRESS

PULL UPS

INCLINE PRESS

discontinuing the exercise immediately and consulting a physician.

A Target Heart Rate Range for Moderate Exercise

Certain individuals may not be able to exercise as strenuously as others. A 60 to 65 percent of maximum heart rate is a safe and still effective target range, especially for an older person. An even lower rate may be necessary for some individuals; therefore, when the intensity is lower, the exercise period should be extended from 30 to 50 minutes.

Indications of overuse include fatigue, poor sleeping patterns, and discomfort for extended periods of time following exercise. If it is difficult to reach a heart rate of at least 60 percent of maximum, a lower rate will give adequate aerobic benefits if the number of repetitions of each exercise is increased.

RELATIONSHIP OF MUSCULAR CONDITIONING TO HEALTH

Muscular conditioning is vital to overall fitness. Most body movements rely on the relationship between the muscular and skeletal systems. Weight training can reduce the resting heart rate and is effective for relieving stress. With the proper diet, body fat can also be reduced while muscle mass is being increased.

Exercising properly with weights is the most effective way to build strength and muscular endurance. Heavy weight resistance with a low number of repetitions builds strength, while light weight resistance with a high number of repetitions builds endurance.

Cardiovascular Benefits

Weight training is essentially anaerobic exercise. While it does not develop the cardiovascular system as well as running, swimming, or bicycling, weight-resistant exercise will develop strength and endurance in the muscles of the legs and upper body so that those muscles do not tire before the cardiovascular system can be improved.

If the intensity level of weight training is kept high, it can have a positive effect on the cardiovascular system. To do this, the exercises must be performed in such a manner as to maintain between 60-90 percent of maximum heart rate. One way to achieve this is to do each set of exercises in a continuous circuit, eliminating rest periods between each set. A high number of repetitions and light weights are usually recommended for this type of training.

A sample of circuit training follows:

The pulse should be checked periodically while exercising to confirm that it is in the target zone. In time, the exerciser will be able to tell by his or her breathing rate whether he/she is in the target zone and will only need to monitor pulse rate after completing the circuit. The weights used can be adjusted to help control the heart rate, but heavy weights should not be used for aerobic conditioning. Running or jumping rope for 30 seconds between sets is another option for maintaining circuit training.

Muscular Benefits

Whether or not one participates in sports and recreational activities, muscular conditioning is important for good physical fitness. Toning, strengthening, flexing, and stretching muscles through a regular program of progressive weight resistance exercises will aid in developing good posture, help prevent injury, increase endurance for daily tasks, create higher energy levels, improve circulation, and add to a person's total self-image. Muscular conditioning is also basic for successful participation in sports that require strength and endurance, and should always supplement aerobic training programs.

Conditioning through weights results in increased muscular strength and size (hypertrophy) that cannot be attained in any other way. Circulation through the muscles increases, and the number and density of capillaries within muscle fiber may also increase. Muscle enzyme levels rise along with blood volume and hemoglobin. Weight training strengthens bones, as well as ligaments and tendons that connect muscles to bones. Some physiologists contend that weight training aids in digestion and can improve elimination.

Applications to Physical Rehabilitation

Progressive resistive exercise (PRE) as a physical rehabilitation technique was the result of medical experiments performed by an orthopedist, Thomas L. DeLorme, MD, following World War II.* Mus-

* T.L. DeLorme, "Restoration of Muscle Power by Heavy Resistance Exercises," *Journal of Bone and Joint Surgery,* 4-B, 1945, pp. 645-667.

GUIDELINES FOR TRAINING WITH WEIGHTS

GENERAL DO'S AND DON'TS

Start with light weights and lift weights progressively. Never start with the heaviest set first: the muscles and tendons are not prepared for sudden exertion.

Do not continue lifting the weights to your maximum ability on the first set of repetitions.

Increase the size of the weights by 5 to 10 pounds after you are able to perform 10 repetitions per set with ease.

Always work the larger muscles of the body first. Small muscles are needed for lifting heavier weights but they become fatigued more quickly than larger muscles. For example, the smaller muscles of the arms often become fatigued before the large muscle groups of the chest or back can be effectively worked.

Learn and always use the correct form for lifting the weights.

FREQUENCY AND DURATION

Frequency and duration depend on personal goals. Maintain a minimum commitment of time in order to keep the body in good physical condition.

An exercise workout 3 times a week is usually needed to gain significant results. Workout sessions should last from 30 to 90 minutes with a rest day in between, which allows the exercised muscles to recover and grow stronger.

A schedule should be established and maintained. Nothing should interfere with your workout time. If you do miss a workout session, get back on schedule as soon as possible.

A competitive body builder or power lifter may train as many as 5 or 6 times a week. Even in this type of routine, each muscle group is usually given a day of rest between workouts.

INCREASING THE NUMBER OF REPETITIONS

The following are Nautilus recommended guidelines for increasing the number of repetitions when training with weights. (These guidelines will be repeated in the introduction of each chapter presenting weight-training exercises.)

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to have a spotter present when using free weights. Certain exercises will require a spotter regardless of skill level (e.g., squats).

GUIDELINES FOR TRAINING WITH WEIGHTS

LEVEL OF DIFFICULTY AND INTENSITY

A general level of difficulty is rated for each of the conditioning exercises in this book. You can vary the level of intensity by adjusting the amount of weight.

Do not lift to your maximum ability on the first few sets of repetitions. In this way you will not experience excess fatigue, which could keep you from finishing the workout.

Work at your own pace. Do not compare your own progress with the abilities of others. Always maintain proper form.

As you improve, you may add more exercises, increase the number of sets, add more weight, and shorten rest periods.

BREATHING

Do not hold your breath while lifting. This could stop the flow of oxygen to the brain, which might result in fainting. Holding your breath while lifting can also close off the escape of air through the glottis, causing a sudden increase in thoracic pressure. For this reason, many physicians do not recommend weight training for postcoronary patients.

Breathe in a rhythmic pattern. Some people find it best to exhale while lifting a weight or moving against resistance and inhale as the weight is lowered or resistance removed. Others find it better to reverse the breathing for certain kinds of exercises, such as those involving movements above the head or in chest expansion workouts.

PROGRESS

Keep a record of the number of sets and repetitions for each exercise in your workout in order to monitor your progress and increase the resistance of the weights in a regulated fashion.

If your goal is to gain or lose weight, gain muscle mass or lose bulk, you may wish to keep a record of your body weight and measurements on a regular basis for future comparison and a record of progress. Photos with front, back, and side views are also helpful.

cular conditioning through PRE is now used in pre- and postoperative care, chronic orthopedic conditions, asthmatic and cardiac conditions, postural problems, postpolio care, neurological conditions, motor coordination, and other postinjury therapy.

Training with weights not only helps one look and feel better, it can also improve self-image. For the disabled individual, increasing muscle size, strength, and endurance can help to restore self-confidence. Feeling strong results in feeling well and healthy. Muscular conditioning can help people with disabilities feel more positive about their bodies by emphasizing areas of the body which still have function and by working to rehabilitate weakened areas.

The results of regular muscular conditioning will be beneficial to the young or old, disabled or nondisabled. Whatever the goal, there is a program that can be tailored to the current physical condition of anyone in reasonably good health. A physician should be consulted before any type of program of muscular conditioning is undertaken.

Principles of Training

Physical fitness programs for rehabilitation, strength conditioning, body building, and toning have different routines. Guidelines are needed to safely and effectively begin any of these programs. In time, individuals usually discover what kind of routine and which exercises are best for their particular needs. An experienced trainer and a rehabilitation team should work with the person with lower limb amputation in designing such a program.

A basic training principle is that each muscle group should be worked every other day, not on consecutive days; thereby giving the muscles a chance to recover from the stresses of exercise. Exceptions to this are the calf and abdomen muscles, which may be exercised every day because they are used in daily activities.

A program should start with a light routine performed three times a week with a day of rest between each session. The program will usually consist of three sets of exercise for muscle groups of each part of the body, with 10 repetitions per set. Each body segment should be worked using one or two different exercises. In the beginning, there should be a 60-second rest period in order to let the muscles recover. Once a routine is established and successfully performed, one can increase the intensity of the workout by gradually reducing the rest time to 30 seconds. For very heavy weight sets, longer rest periods are acceptable.

In the first week, only one set per muscle group should be performed in order that the movements of each exercise may be learned and the muscles allowed to adjust to the new stresses. Two sets may be performed during the second week and three sets during the third week. This routine should be continued for a total of 8 weeks. When the eighth week is completed, the program should be evaluated. If this routine is suitable, the exerciser may continue increasing the number of sets and weights each week. Intermediate and advanced conditioning programs require increasing weight repetitions and sets, as well as adding new exercises.

WARM-UP AND COOL-DOWN EXERCISE

Flexibility and range of motion are developed and maintained by calisthenics and stretching exercises before and after the strengthening routine.

A good warm-up prepares the muscles, ligaments, and tendons for action. It steps up blood circulation, raises the body temperature, and enhances flexibility of the joints. By limbering the muscles and joints, these exercises can prevent many injuries. Warming up before strenuous or active exercise is especially important in cold weather.

The warm-up should consist of some calisthenics, stretching exercises, and light resistance exercises. It should take from 10 to 20 minutes. Each body part should be moved through a full range of motion, first without resistance, then with light resistance. (Most experienced weightlifters use a light first set of their resistant exercises as a part of their warm-up.) Bicycling and running in place are also good forms of warming up for weight-resistant exercises.

Cooling down after completing the entire exercise routine is very important. It helps the body make the transition from high-intensity activity to a normal level. Stretching and low-grade calisthenics are best for the cool-down. Cool-down stretches can help prevent muscle soreness. A light jog or bike ride is also a useful means of cooling down. At least 10 to 20 minutes should be allowed for cool-down exercises.

Many weightlifters cool down individual body parts as they complete sets of exercises by doing 8 to 10 repetitions using a lighter weight than that used in the routine.

BASIC BEGINNING WORKOUT PROGRAM
Warm-up Exercises; repeat for Cool-down Exercises

Title	Chapter	Page
3-5 minutes: calisthenics		
Jumping Jacks	5	40
Neck Rolls	5	41
Trunk Twists	5	45
Supine Leg Raise	10	120
Push-ups	11	144-148
3-5 minutes: stretches		
Overhead Bent-Arm Stretch	6	53
Shoulder/Arm Stretch	6	54
Quadriceps Stretch	6	63-64
Hamstring Stretch	6	65

* Include any additional calisthenics or stretches you feel are appropriate.

* 3-5 minutes of stationary bicycling (see Chapter 18) or jogging (see Chapter 15) also may be used for warm-up and cool-down exercises.

BASIC BEGINNING WORKOUT PROGRAM
Resistance Exercises

Repetitions	Sets	Title	Chapter	Page
8-12 or 15-20	3	Nautilus Abdominal Chair	10	129
8-12 or 15-20	2-3	Single Knee Extension	9	93
8-12 or 15-20	2-3	Leg Curl	9	109
8-12 or 15-20	2-3	Push-ups	11	144-148
8-12 or 15-20	2-3	Nautilus Bench Press	11	152
8-12 or 15-20	3	Overhead Press	8	82
8-12 or 15-20	3	Nautilus Lat. Pull-down	12	169
8-12 or 15-20	3	Triceps Curl	7	71, 74
8-12 or 15-20	3	Seated Arm Curl	7	76

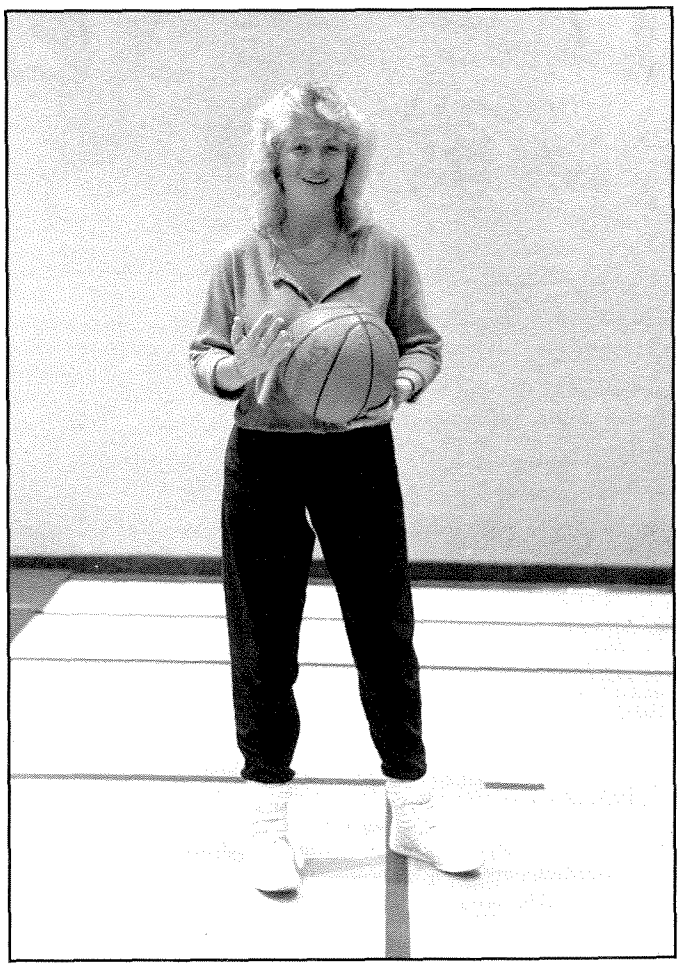
PROFILES OF THE EXERCISERS

Samantha Ellis

Samantha Ellis is an exceptional person. She is missing both limbs above the knee, but the ability to bear weight on the end of one of her residual limbs has given her an advantage in being able to develop her remarkable skills in physical activities.

The prostheses Ms. Ellis uses for most activities are Endolites with Contoured Adducted Trochanteric/Contained Alignment Method (CAT/CAM) Flexible Sockets made with a polyethylene inner socket and polypropylene outer frame socket. She also uses a Mauch Swing Phase Hydraulik™ Knee Unit for increased knee stability, along with the Endolite Stabilized StanceFlex Knee.

Ms. Ellis swims to stay in good physical condition and also plays golf. She discovered the benefits of health club equipment for strength conditioning and has taken up downhill skiing for recreation. Born and raised in England, Ms. Ellis now works part of the year in the United States at a.f.i. Endolite in Hialeah, Florida as a customer relations representative.

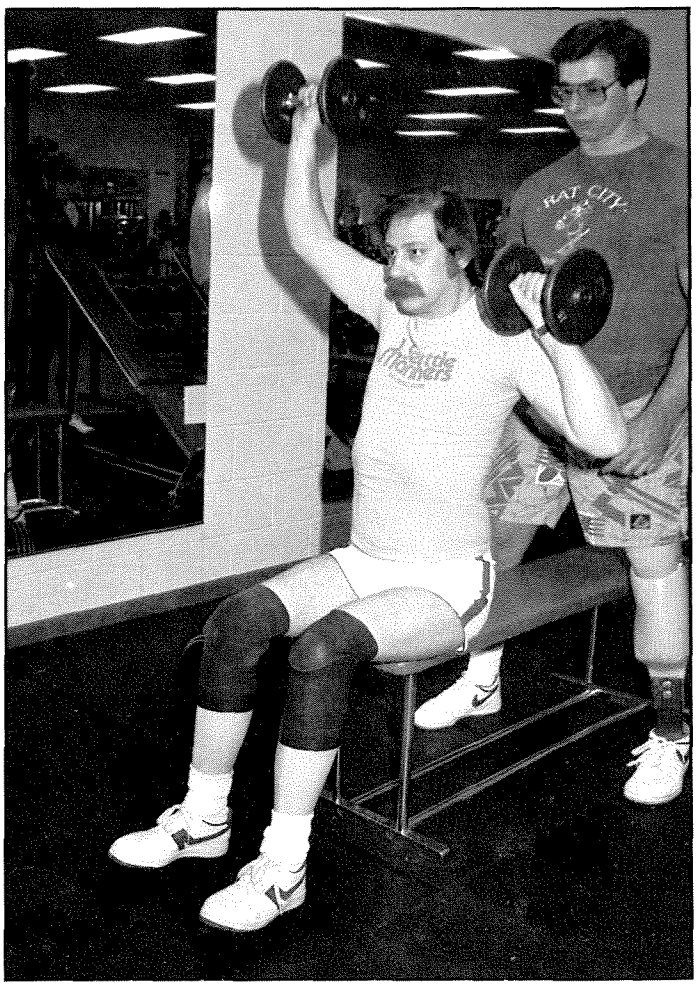


John Everett

John Everett is a Vietnam veteran who has bilateral below-knee amputations. He works out regularly with the same prostheses that he uses for his daily activities. He rides a stationary bicycle and walks for aerobic exercise. In the winter months, he enjoys downhill skiing. He feels that exercise enables him to be an active participant in recreational sports, as well as helping him to have more energy in his everyday routine.

His prostheses are exoskeletal in design with Seattle Feet, pelite liners, silicone end pads, New Skin cosmetic finishing, USMC's Adjustable Leak Rate Small Suction Socket Valves, and the ActivSleeve Suspension System. Although the ActivSleeve System produces a suction-type suspension, the addition of the small suction valve helps to purge any extra air from the socket (a 3-ply socket fit with a DAW Sheath underneath), which ensures true atmospheric suspension. When working out in the gym, Mr. Everett sometimes adds an extra ply sock and interchanges his pelite liner with the PM liner, which helps absorb the extra forces placed on his residual limbs.

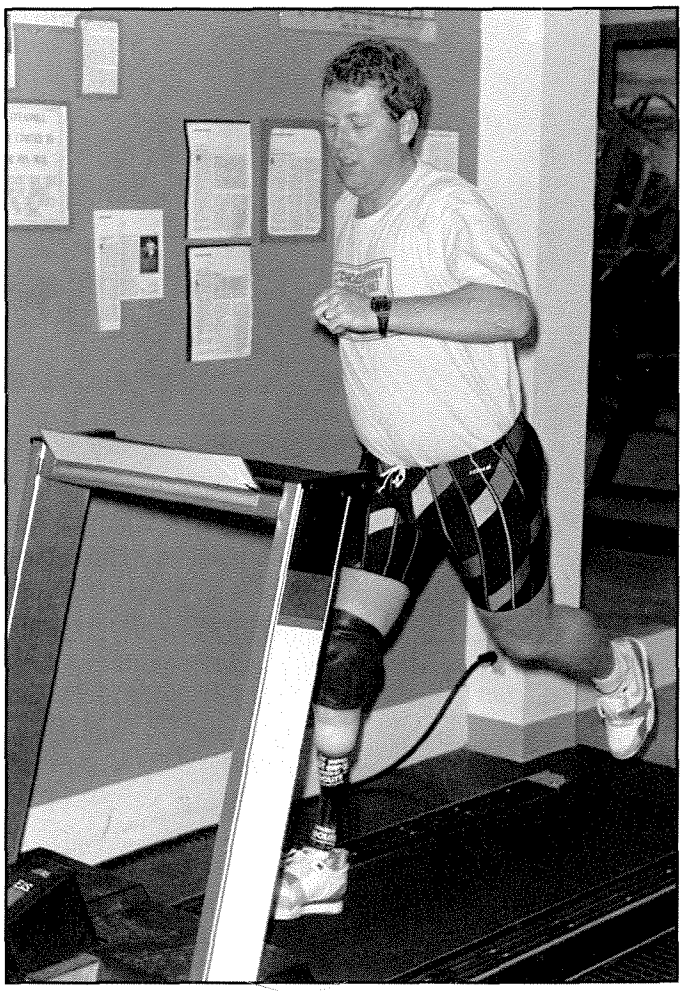
Mr. Everett counsels people with drug addictions, does peer counseling in amputee support groups at Harborview Hospital and other locations in the Seattle area, and is a volunteer at the Prosthetics Research Study, a firm in Seattle.



Richard Hughes

Richard Hughes has a below-knee amputation. He enjoys a variety of sports and stays in good physical condition by sculling in his own boat. He competes in triathalons, which requires him to maintain several types of prostheses for several sports activities. Mr. Hughes is chief of the Technical Marketing Department for a.f.i. Endolite in Hialeah, Florida. He has also worked as a clinical prosthetist.

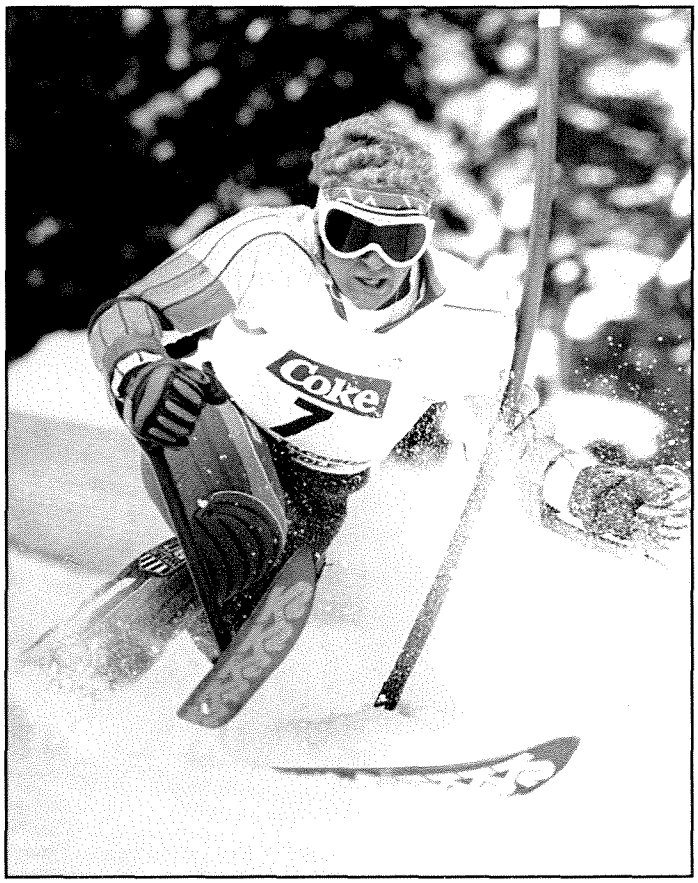
The artificial limb Mr. Hughes uses most frequently consists of a skin-fit suction below-knee prosthesis with a flexible wall polyethylene inner socket and a polypropylene outer frame socket, which is cut out over relief areas for increased comfort and lighter weight. An Endolite prosthesis is also incorporated into the design with an adapted Seattle Foot and the ActivSleeve Suspension System.



Greg Mannino

If Greg Mannino looks familiar to you it is because he is a highly visible professional amputee athlete. He trains year-round to maintain his ranking as one of the top downhill three-track skiers in the world. When he is not race training in Vail, Colorado, or traveling to a ski race, he is working on staying in good physical condition by lifting weights regularly. He also enjoys bicycling, running, cross-country skiing, and horseback riding.

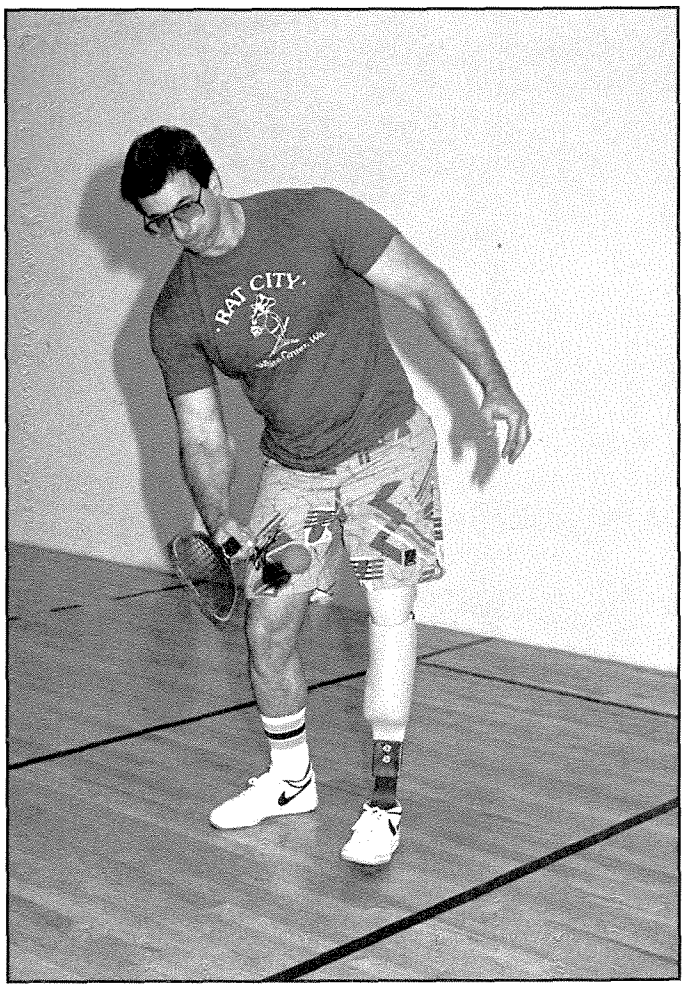
Mr. Mannino, who has an above-knee amputation, wears an Endolite prosthesis with the Stabilized StanceFlex (Bouncy) Knee, with the Mauch Swing Phase Hydraulik Knee Unit. He feels that the comfort of his CAT/CAM flexible walled socket has contributed to his ability to achieve a high level of performance.



Mike Nitz

Mike Nitz was a competitive power lifter before losing his leg above the knee. He has since returned to the gym and has designed a program that accommodates for his limb loss and prosthesis and still allows him to maintain a high level of intensity during workouts. The only exercises he has not continued are standing squats and the dead lift.

Mr. Nitz was back at work soon after receiving his first prosthesis. Because his job as a sanitation engineer is physically demanding, he feels it is not only important for him to stay in good physical condition but also to have a prosthesis that can perform adequately. He uses a Narrow ML Flexible Brim Socket with a Mauch Swing and Stance Phase Knee Control Unit (Mauch SNS Knee Unit) and the Flex-Foot.

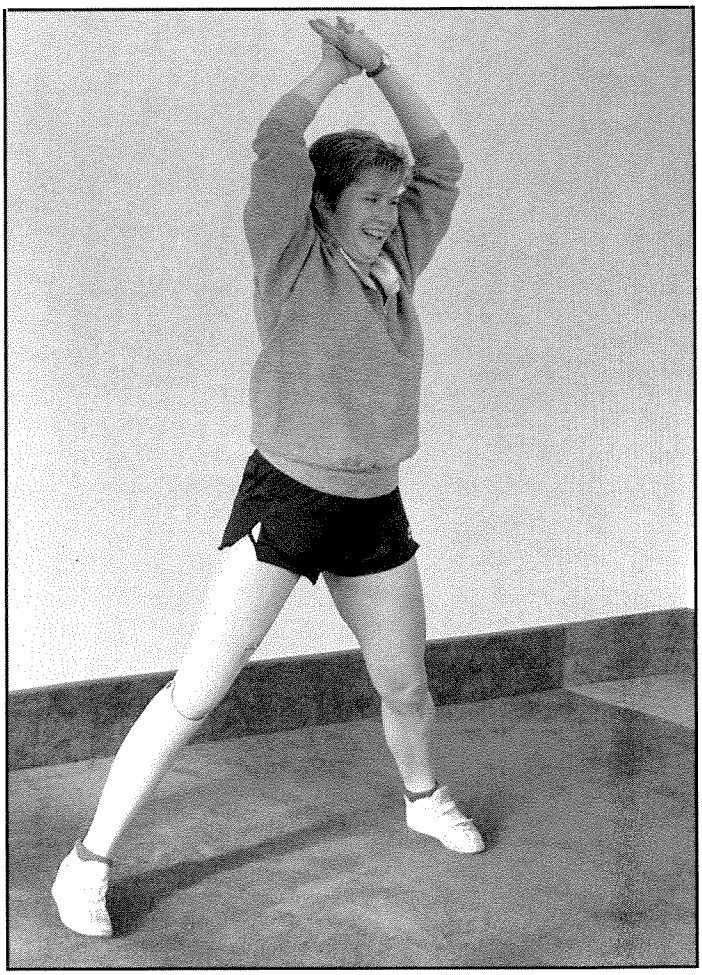


Linda Pedersen

Linda Pedersen works out on Nautilus equipment at least three times a week. She enjoys snow skiing in the winter and has competed in regional ski races sponsored by the National Handicapped Sports and Recreation Association (NHSRA). She plays tennis, water skis, and has played several seasons of crutch soccer as co-captain of a Seattle, Washington team. A former track star in high school prior to losing her leg above the knee, Ms. Pedersen is an excellent foot-over-foot runner.

She uses an everyday walking prosthesis for most of her activities. It consists of a quadrilateral suction socket, Mauch SNS Knee Unit, and Otto Bock SACH Foot. This exoskeletal prosthesis is simple in design and requires very little maintenance. For running, she often wears the Terry Fox Spring Shank and the Seattle Foot.

Ms. Pedersen is an administrative assistant in the Property Department of the Johnson and Higgins Insurance Brokerage firm in Seattle and does volunteer work at the Seattle Prosthetic Research Study.

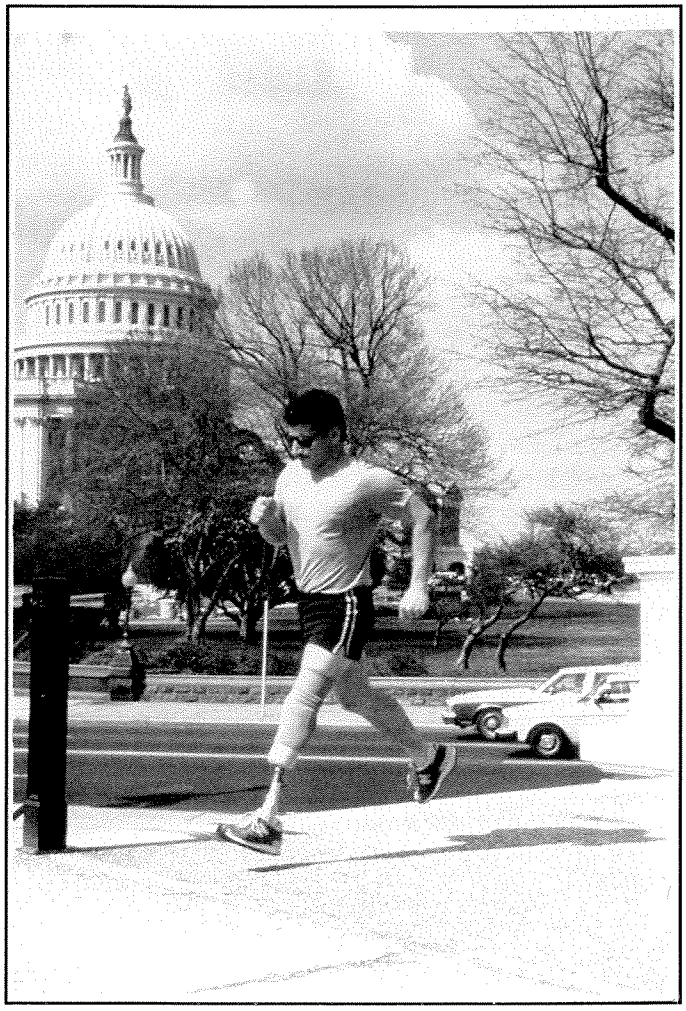


Albert Rappoport

Albert Rappoport, one of the authors of this book, had been athletic prior to losing his leg below the knee and has worked to regain his abilities. He enjoys weight training, swimming, and skiing for fitness and plays tennis and racquetball.

Mr. Rappoport wears primarily one prosthesis for his everyday activities, as well as for the weightlifting exercises shown in this book. The below-knee exoskeletal prosthesis uses a pelite liner, silicone end pad, wool sock and sheath, ActivSleeve Suspension System, and Seattle Light Foot. Mr. Rappoport also wears a Flex-Foot prosthesis fabricated with a graphite epoxy socket for activities that involve running. The socket is a duplicate of that used with his regular prosthesis and utilizes the same liner. Stationary rowing photos show him using an endoskeletal prosthesis with Otto Bock components, ActivAnkle, and the Carbon Copy II Symes Foot.

Mr. Rappoport is a prosthetist in private practice and director of the Performance Prosthetic-Orthotic Center, Santa Monica, California. Previously, he was chief research prosthetist at the Prosthetics Research Study, Seattle, Washington. He also has worked as a Nautilus instructor and has taught courses in physical conditioning at the University of Southern California.



5

CALISTHENICS

Calisthenics are an integral part of a well-rounded physical fitness program because they develop both muscular and aerobic endurance. They are used to warm up and limber the body for sports activities or weight-resistant training and also for cooling down afterward. Calisthenics are low-resistance, high-repetition training.

Individuals can test their level of fitness with push-ups, toe touches, knee-bends, or sit-ups. Beginners will find that more than just a few repetitions require a combination of strength and muscular endurance. Certain calisthenics are helpful in training for particular sports. For example, push-ups develop the upper body endurance needed for rowing.

Special equipment is not necessary and the exercises allow for concentration on particular areas of the body. The calisthenics selected for this book can be adapted to the special needs and capabilities of most people with lower limb loss.

Supplements

Stair climbing and jumping rope are not considered to be calisthenics but may supplement a calisthenics routine.

Conventional stair climbing can be practiced by those people with lower limb loss who are skilled in using their prosthesis. The hand rail may be used occasionally for balance, but this should not detract from the workout. Computerized stationary climbers such as the StairMaster® are excellent for aerobic training, and provide a good workout for the legs. Hand rails are used for maintaining balance.* The Versa Climber is a ladder-like stationary climbing device that works the upper and lower body while training the cardiovascular system.

Many athletes jump rope as part of their warm-up and cool-down routines. A person with a lower limb amputation may jump rope with or without a prosthesis. Jumping rope develops strength, coordination, and endurance in the sound limb, but it can be difficult to master jumping alternately on each leg because of the impact on the residual limb. Landing on two legs creates less stress on both legs. When jumping without a prosthesis, great stress is placed on the sound limb. The stress can be lessened by jumping on a large mat, an impact-resistant floor, grass, or other forgiving surface.

A person with a lower limb amputation should not use stair climbing or jumping rope exclusively to achieve aerobic fitness. They should be considered only as supplemental activities to warm-up or cool-down exercise. Begin with 10 to 15 seconds of exercise and rest 30 seconds to 1 minute between sets. Gradually build up to three 1-minute sets.

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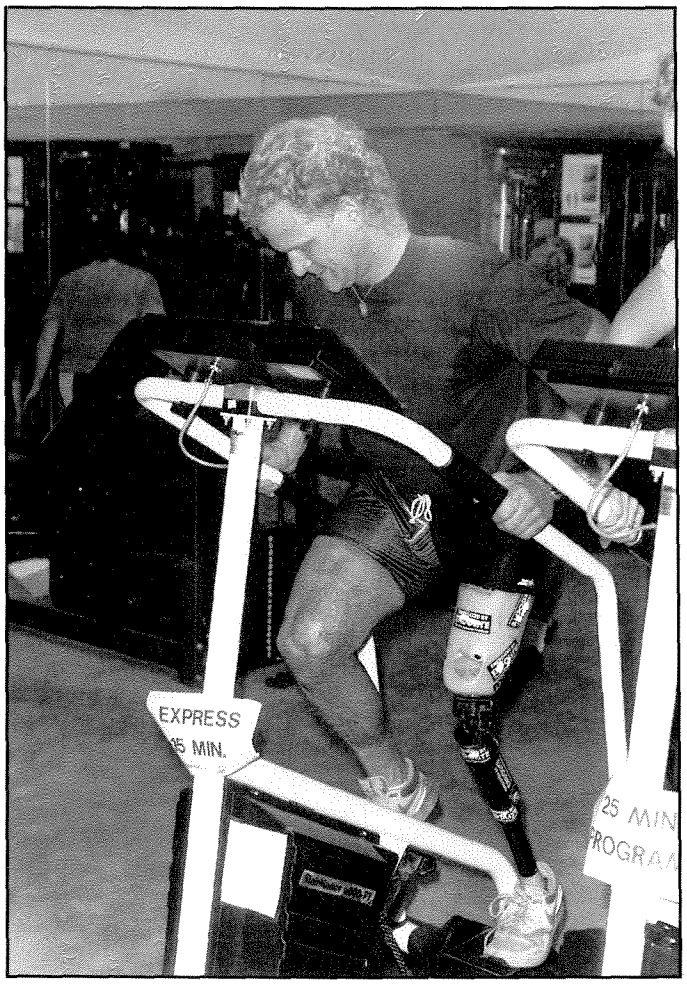
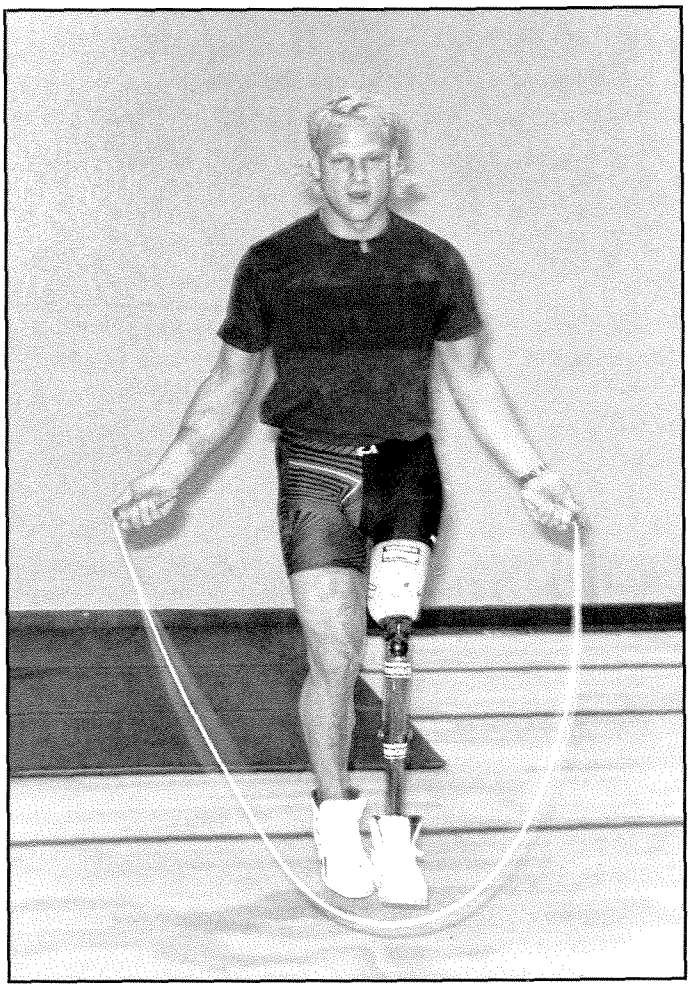
* Users are cautioned not to grip the hand rails tightly. A recent study reported deep palmar branch ulnar neuropathy in two subjects as a result of excessive pressure to the palms while using the StairMaster. (Alvin Glass, "StairMaster Syndrome: A Deep Palmar Branch Ulnar Neuropathy." *Archives of Physical Medicine in Rehabilitation,* 70(11): A-89 [Abstract], October 1989.)



Stair climbing Many people go out of their way to avoid climbing stairs; however, with the advent of computerized machines that can vary resistance, this aerobic exercise is gaining popularity at many health clubs. Greg Mannino works out against a high setting of resistance.



Jumping rope This is a simple way to work the cardiovascular system. A person wearing a prosthesis or jumping without it should jump rope only in brief intervals as part of a warm-up or cool-down routine.

CALISTHENICS ROUTINE		
Muscle	**Exercise**	**Title**
General Warm-up/Cool-down	1	Jumping Jacks
Neck/Sternocleidomastoid	2	Neck Rolls
Neck/Sternocleidomastoid	3	Free-Hand Neck Resistance
Shoulder/Upper Body	4	Arm Circles
Abdomen/Upper Body	5	Alternating Toe Touch with Bar
Waist/Upper Body	6	Trunk Twists
Abductor/Outer Thigh	7	Abductor/Adductor Leg Raise
Abductor/Outer Thigh	8	Prone Leg Extension
Gastroc/Soleus	9	Standing One-Legged Toe Raise
OPTIONS: Jumping rope, stair climbing		

EXERCISE 1. JUMPING JACKS

PURPOSE

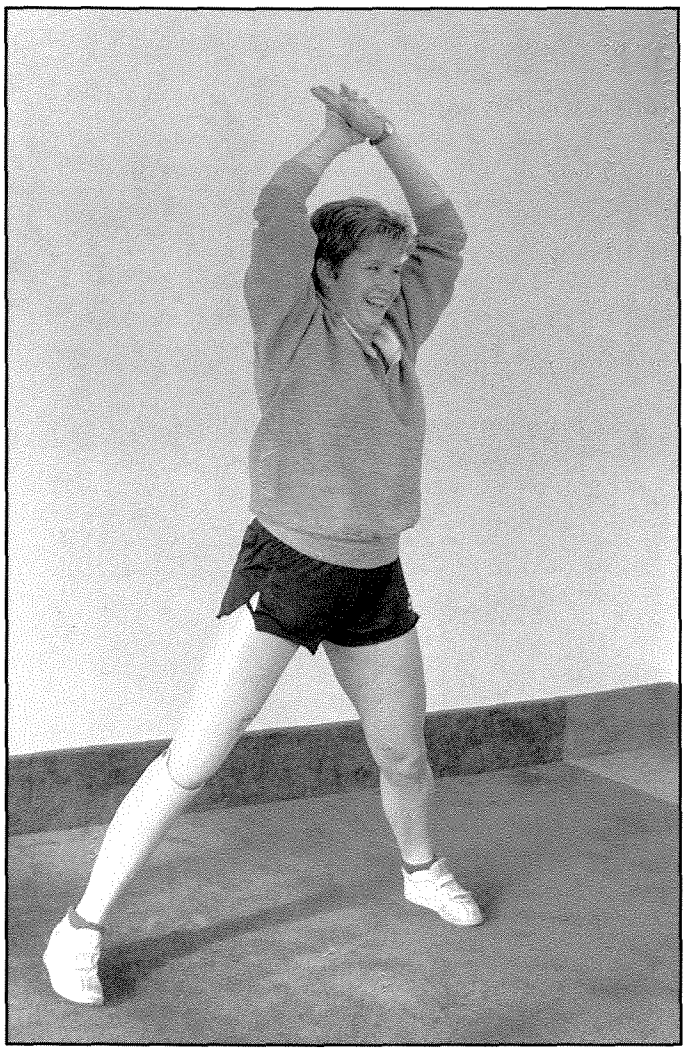
Warm-up and/or cool-down exercise for the entire body.

PROCEDURE

- Begin by standing with feet together and hands at sides.
- Simultaneously bring your hands together directly above your head, jump, and split both legs wider than shoulder-width, as shown in photo.
- Without stopping, jump both legs back together and bring arms down to the sides of the body.
- Gradually work up to at least 20 repetitions.

MODIFICATIONS

If jumping on the residual limb causes pain, simply favor the sound side. A flexible AK brim or a CAT/CAM or Narrow M/L Socket will provide stability and comfort. BK-level individuals who experience discomfort may require socket modifications.



This exercise is used as warm-up and cool-down for the muscles of the upper and lower body.

NOTE

Almost all the jumping and push-off is done by the sound leg. The side with the prosthesis must keep pace; move the leg away from the midline and back again to where the heels are nearly touching in a fluid motion.

EXERCISE 2. NECK ROLLS

PURPOSE
Stretches and exercises the neck muscles.

PROCEDURE (CLOCKWISE ROTATION)
- Bend the neck until the chin touches the chest.
- Roll the head to the right until the right ear touches the right shoulder.
- Roll the head back, bringing the chin up as far as possible.
- Roll the head to the left until the left ear touches the left shoulder.
- Repeat steps 1 through 4.
- Rest (20-30 seconds); then perform the exercise in two counter-clockwise rotations. Fifteen to 20 repetitions are recommended for each rotation sequence.

MODIFICATIONS
None.

This is a preliminary exercise. It may be done while standing or seated.

EXERCISE 3. FREE-HAND NECK RESISTANCE

PURPOSE

Develops strength in the neck muscles. This exercise is often used as a warm-up for weightlifting exercise.

PROCEDURE: FRONT

- As shown in the photo, interlock fingers and place both hands against the forehead. Push the hands and head against each other.
- Start with the head back and push forward.

PROCEDURE: BACK

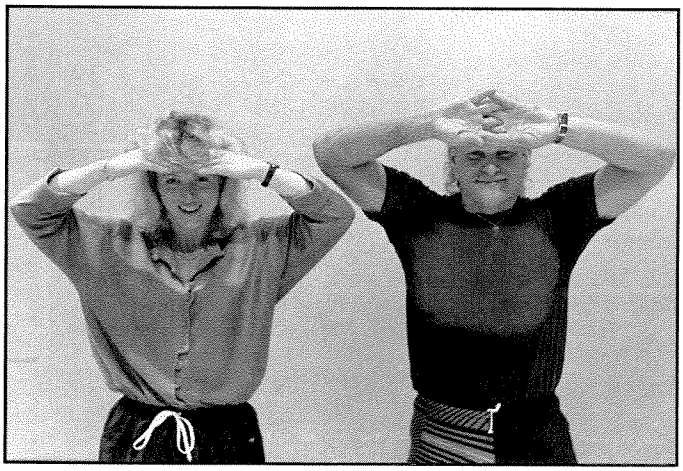
- Interlock fingers and place both hands on the back of the head. Again push the hands against the head.
- Start with the head forward and push backward.

PROCEDURE: SIDES

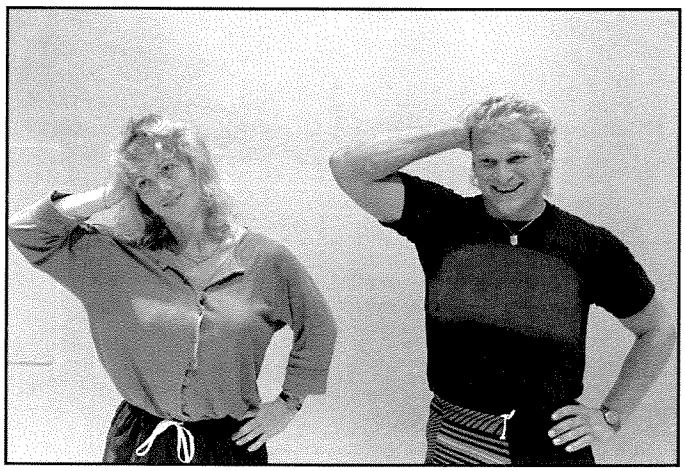
- As shown in the photo, place the right palm against the right side of the head.
- Start with the head on the left shoulder and push it against the hand as the hand resists. Continue until the head is resting on the right shoulder.
- Do the same with the left hand on the left side of the head.
- Repeat the entire sequence (front to back to sides) 15 to 20 times.

MODIFICATIONS

None.



Samantha Ellis and Greg Mannino demonstrate front resistance.



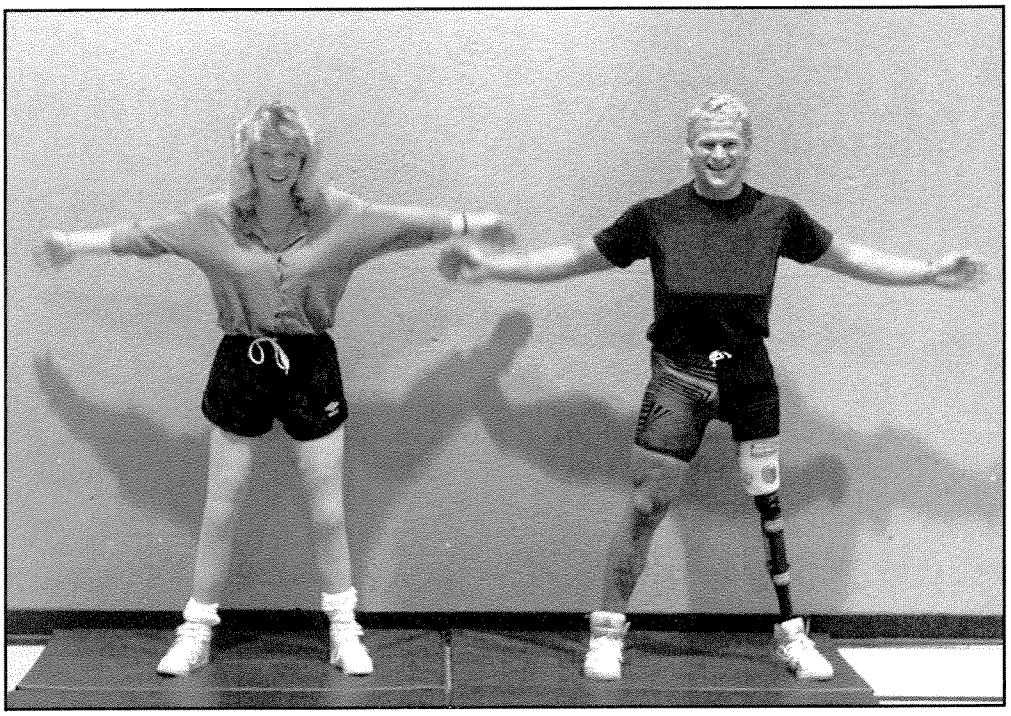
Ellis and Mannino demonstrate side resistance.

EXERCISE 4. ARM CIRCLES

PURPOSE
Exercises the shoulders, arms, and the upper back.

PROCEDURE
- Stand with the feet shoulder-width apart and arms full length at each side. Bring both arms to shoulder height, as shown, and move them in a small circular motion.
- Begin by circling forward for 15 to 20 repetitions, then circle the arms backward for 15 to 20 repetitions.
- Bring both arms down to the sides of the body and relax for about 10 seconds before beginning a second set of the exercise.
- Vary the size of the circles from small to large and increase the speed. This will assist in limbering the shoulders and upper back.

MODIFICATION
This exercise may be performed while either standing or sitting.



Ellis and Mannino perform this exercise as a warm-up for the shoulders, upper back, and arms.

EXERCISE 5. ALTERNATING TOE TOUCHES WITH BAR

PURPOSE

Warm-up and cool-down exercise for muscles of the upper body, shoulders, arms, abdominal muscles, and the hamstrings. The bar helps to keep the shoulders straight while performing this exercise.

PROCEDURE

- Place a bar (about 36 inches in length) on the shoulders and hold it on both ends as shown in the photo.
- Bend from the waist, keeping the torso approximately parallel to the floor. (Try not to bend the knees.)
- Twist the body in a smooth motion so that the left hand touches the right foot, as shown. The right arm will be extended in the air.
- Raise to an upright position and repeat for the other side.
- Fifteen to 20 repetitions are recommended.
- Suggested sequence:
  - — Toe touch left hand to right foot.
  - — Upright.
  - — Toe touch right hand to left foot.
  - — Upright.
  - — Repeat the sequence 15 to 20 times.

MODIFICATIONS

The anterior brim of an AK socket may impair one from touching the floor. A flexible brim and Narrow M/L socket can help.

This exercise may be carried out in the sitting position, which increases trunk stability and decreases back stress.

CAUTION

Stretch gradually, do not bounce. Bouncing may stretch the muscles too far and possibly cause injury.

Warm-up and cool-down exercise that helps develop muscle tone on the waistline and upper body, including increased flexibility of the back.

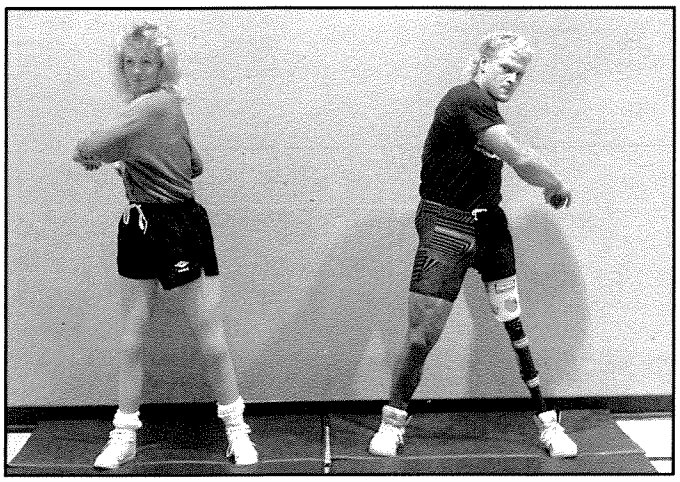
EXERCISE 6. TRUNK TWISTS

PURPOSE
Helps develop muscle tone on the waistline and upper body, including increased flexibility of the neck.

PROCEDURE
- Keep the feet planted on the floor and spaced a bit wider than the shoulders.
- Raise both arms to chest height, keeping the elbows slightly bent.
- Twist side to side from the waist, as shown in the photo. Try to rotate far enough so that each shoulder reaches at least the midline of the body.
- Twist on both sides 15 to 20 times.

VARIATION
- Place a bar (about 36 inches in length) on the shoulders and hold it at both ends.
- Keeping both feet on the floor with knees straight but relaxed keep hips still and twist from the waist to each side, as shown in the photo.

MODIFICATION
This exercise may be performed from a seated position.


Ellis and Mannino twist from side to side in a rotary motion.

CAUTION

Stretch gradually, do not bounce. Bouncing may stretch the muscles too far and possibly cause injury.


Mannino demonstrates a variation using a shoulder bar.

EXERCISE 7. ABDUCTOR/ADDUCTOR LEG RAISE

PURPOSE

Works the muscles of the inner thigh and outer thigh, which, when strengthened, improve balance and control while walking and in other ambulatory activities.

PROCEDURE 1: ABDUCTORS

- Lie on one side with one arm holding the head up and the other resting at the waist (beginners may use this arm as additional support by placing the palm of the hand on the floor).
- Keeping both legs straight, raise the top leg about 12 to 15 inches from the floor, as demonstrated in the top and middle photos.
- Hold at the high position for a few seconds before lowering the leg.
- Raise the leg up only high enough to maintain tension on the abductors, as seen in the photo.
- Fifteen to 20 repetitions are recommended.

NOTE

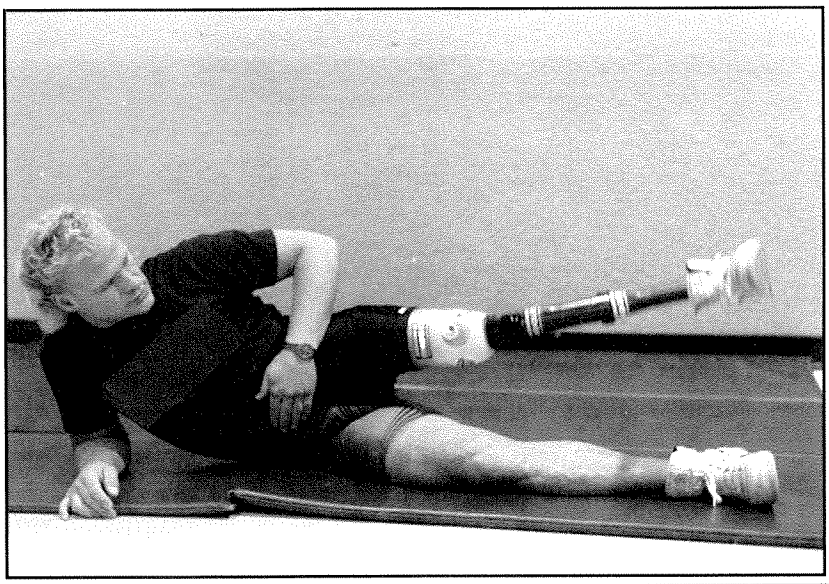
In the middle photo, Linda Pedersen demonstrates a wide range of motion to include a stretch in the exercise. However, the tension on the abductors is no longer effective at this height.

PROCEDURE 2: ADDUCTORS

- Lift the bottom leg in front of the other leg, as shown in the photo. (You will not be able to raise it as high as you were able to raise the top leg.)
- Hold the high position for a few seconds before lowering the leg.
- Fifteen to 20 repetitions are recommended.

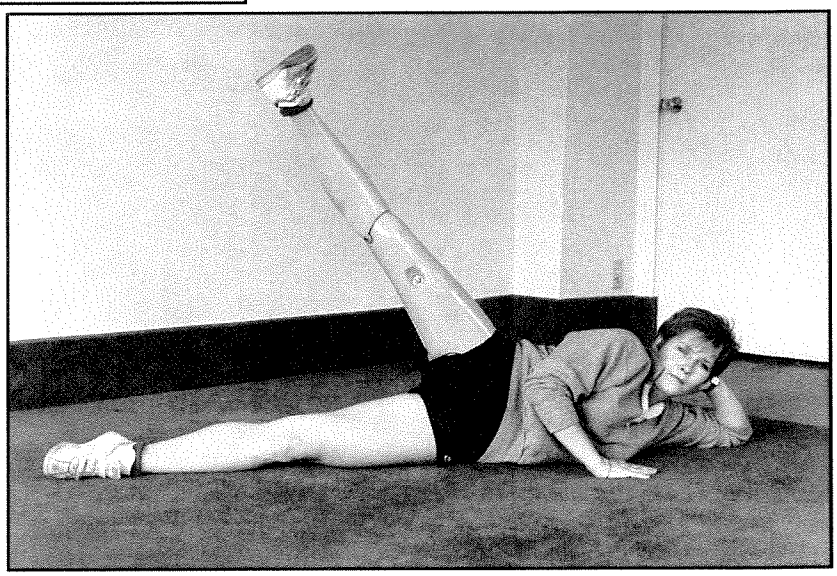
MODIFICATION

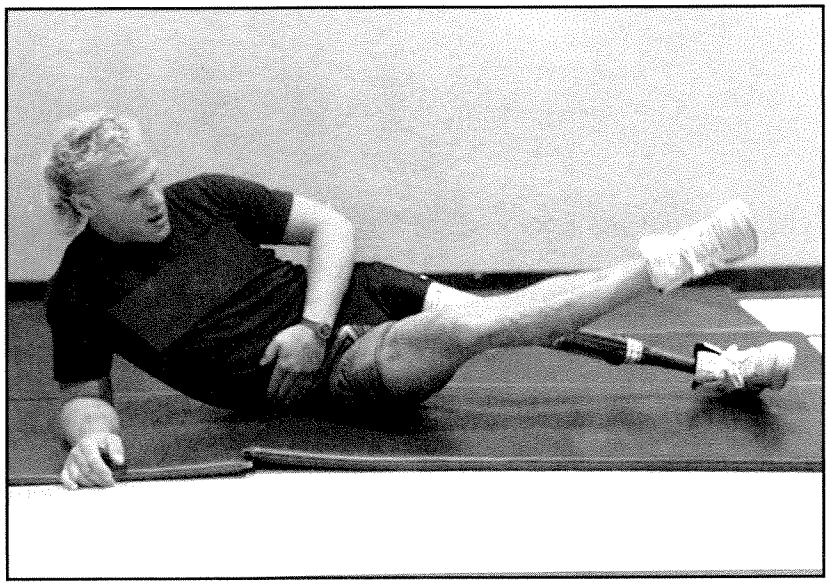
Manually lock the knee for AK prostheses.



Mannino works the abductor thigh muscles.

Pedersen strengthens the hip abductors with a scissors-type stretch added to the exercise.





Mannino works the adductor thigh muscles.

EXERCISE 8. PRONE LEG EXTENSION

PURPOSE
Develops the hamstring and gluteal muscles.

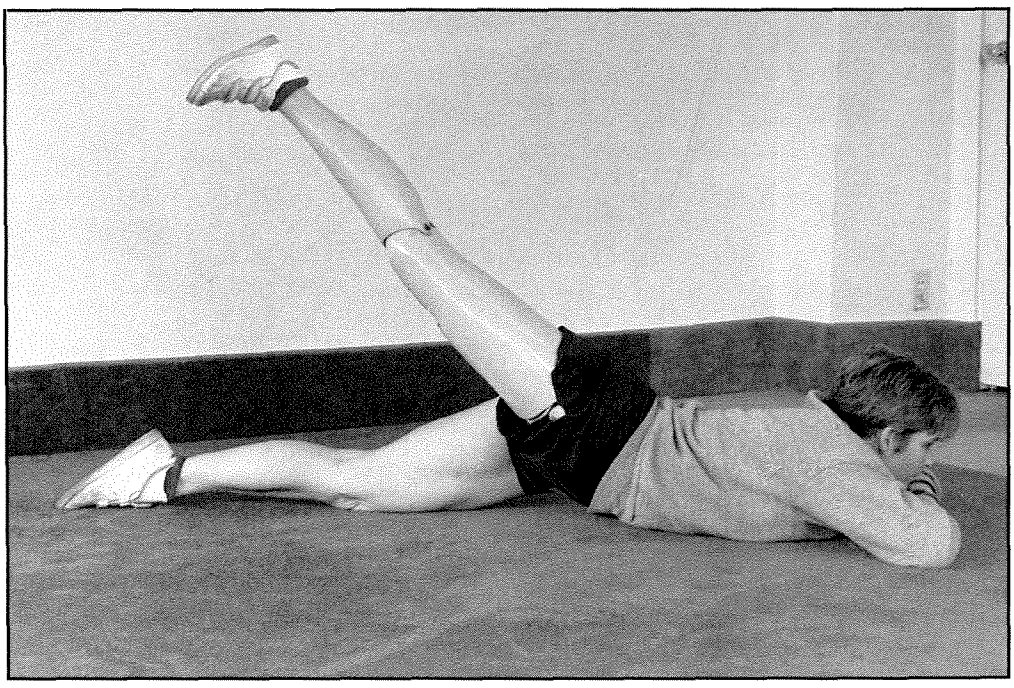
PROCEDURE
- Lie on the floor in a prone position.
- Alternate raising one leg at a time by extending from the hip. Keep both legs as straight as possible.
- Bring each leg up as high as possible in order to gain the full benefit from the exercise before lowering the leg.
- Work each leg separately doing 15 to 20 repetitions per set, then switch legs. No rest is necessary between sets.

VARIATION
Hold the fully raised position for a few seconds, contracting the muscles of the hamstring and gluteus. Then lower the leg slowly to the floor.

MODIFICATIONS
This exercise may be performed with or without the prosthesis. However, the prosthesis provides more weight resistance, thus working the muscles harder.

CAUTION

Low back hypertension against resistance can cause undue stress to the spine. Observe caution; do not strain this area.



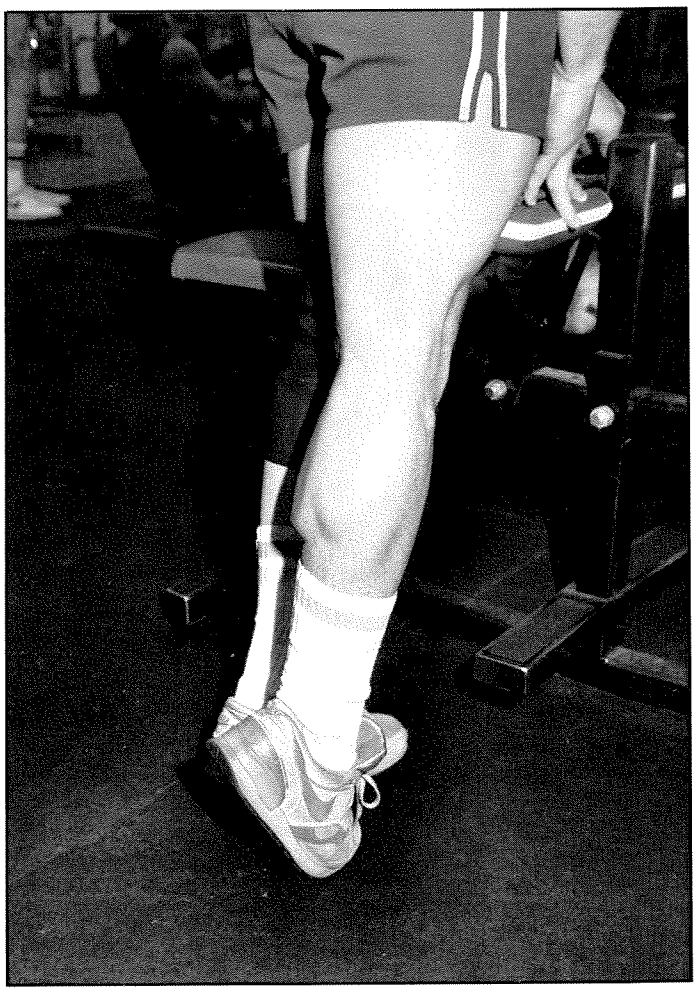
Pedersen exercises the prosthetic side.

EXERCISE 9. STANDING ONE-LEGGED TOE RAISE

PURPOSE
Develops strength and definition in the gastrocnemius/soleus muscles.

PROCEDURE
- Stand with your feet close together. Hold onto a support with one or both hands.
- Raise up on your toes on the sound side as shown in the photo. Hold the position at the top for a few seconds before lowering the heel.
- Perform this exercise in a slow, controlled motion.
- For full calf development use three positions:
  - — Point toes straight ahead to work calf muscle in general.
  - — Point toes inward to work outer calf specifically.
  - — Point toes outward to work inner calf specifically.
  - — Fifteen to 20 repetitions are recommended.

VARIATION
For a greater range of motion, stand on a raised step with your heel off the edge so that it may be lowered further. The standing toe raise may also be done while using barbells.



The toes are pointed inward, working the outer calf.

6

STRETCHING

When muscles are trained through conditioning exercises they can become tight. Stretching extends the muscles, helping them relax and maintain flexibility. It also relieves stress and contributes to mental as well as physical health. Stretching exercises should always be included in warm-up and cool-down routines for muscle conditioning or sports.

There are two basic kinds of stretches: static and dynamic. A static stretch is one in which a position or a posture is extended and held for a period of time. Yoga is an example of static stretch exercise. Most of the stretches included in this book are static exercise. Dynamic stretching involves range of motion, such as in calisthenics and aerobic dance. Some of the calisthenics in Chapter 5 involve dynamic stretching. People just beginning an exercise program should concentrate on static stretching, adding dynamic stretches as they develop flexibility.

Flexible joints and a limber body reduce the risk of injury in physical activities. The most effective and the safest way to develop flexibility is through slow, steady, and regular progress. Before beginning your program, work out a routine that is suited to your own level with your rehabilitation team or with experienced exercise therapists.

How to Stretch Correctly

The stretch should be held for approximately 10 to 30 seconds, and only to the point where mild tension is felt in the muscle. Relax as the stretch is held. Mild tension in the muscle should subside as the position is held. If it does not subside, ease tension on the muscle to a comfortable degree of tension where the stretch can be held. After the first stretch has been held, come back to the resting position completely before the next stretch.

The second stretch for the same muscle group is called the "developmental stretch" In this stretch, try to move a fraction of an inch further than the first stretch, creating a mild tension of the muscles while holding the stretch for the same number of seconds as the first one.

Prostheses may restrict the natural range of motion. For example, the person with a below-knee amputation will be restricted when flexing the knee, while someone with an above-knee amputation will be restricted when flexing the hip. Modified trim lines and flexible brim sockets are helpful in increasing flexibility.

STRETCHING EXERCISES		
Muscle	**Exercise**	**Title**
Shoulder/Upper Body	10	Overhead Stretch
Shoulder/Upper Body	11	Overhead Bent-Arm Stretch
Shoulder/Upper Body	12	Shoulder/Arm Stretch
Gastroc/Soleus	13	Standing Calf Stretch
Hamstrings	14	Standing Toe Touch
Hamstrings	15	Seated Toe Touch
Hamstrings	16	Hurdler's Stretch
Quadriceps	17	Anterior Thigh Stretch
Quadriceps	18	Standing Quadriceps Stretch
Quadriceps	19	Double Quadriceps Stretch
Gluteus Maximus/Hip	20	Seated Hip and Upper Hamstring Stretch
Inner Thigh/Groin	21	Standing Split
Lower Back/Abdomen	22	Prone Trunk Extension/ Low Back Arch

EXERCISE 10. OVERHEAD STRETCH

PURPOSE

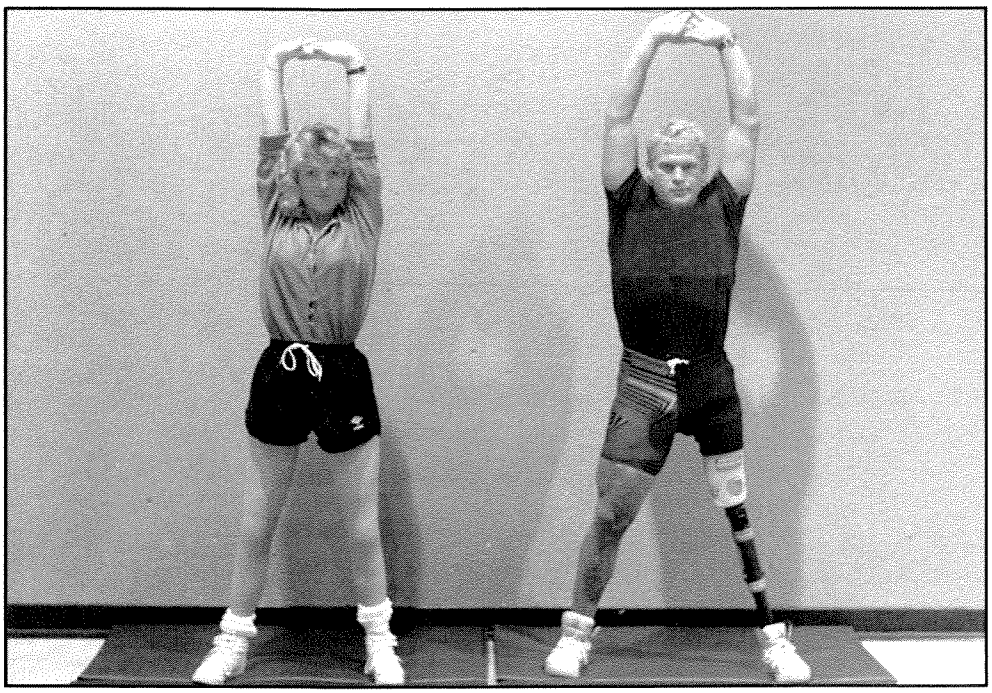
Stretch, warm-up, and cool-down for the muscles of the arms, shoulders, and upper body. This is also a relaxing deep breathing exercise.

PROCEDURE

- Stand with feet about shoulder-width apart.
- Raise both arms above the head and interlace fingers. Extend the elbows directly over the head and reach for the sky.
- Inhale and expand the chest while pulling in the stomach. Hold the position for a few seconds.
- Slowly exhale as the arms are brought down to the sides again.
- This exercise may be performed from a seated position.

MODIFICATIONS

The intensity of the stretch can be increased by raising the arms slightly behind the head rather than straight up from the head. However, raising the arms behind the head requires good standing balance.



Beginners should stand against a wall or other support surface until good standing balance is developed.

EXERCISE 11. OVERHEAD BENT-ARM STRETCH

PURPOSE

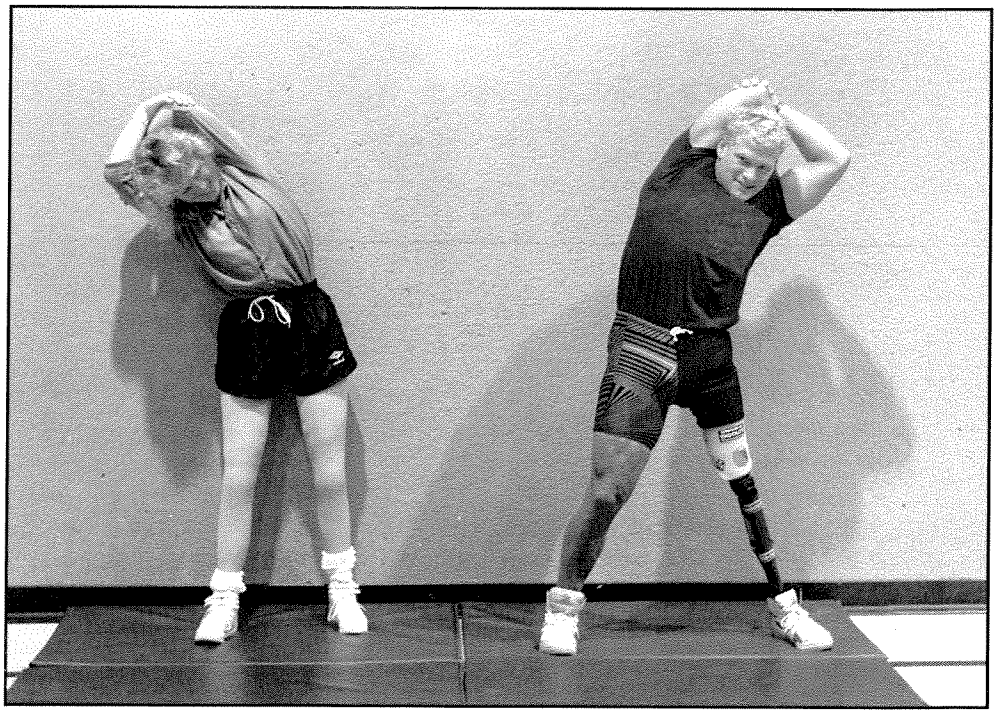
Stretches and exercises muscles on the side of the trunk, including the triceps, shoulder, latissimus dorsi, and the obliques.

PROCEDURE

- Stand with the feet about shoulder width apart or slightly wider. The knees may be slightly bent to assist in maintaining balance.
- Raise both arms above the head. Grab hold of the left elbow from behind with the right hand and pull the left arm as if to bring it over the head.
- Bend as far as possible from the waist on the right side as the left elbow is being pulled. Hold the position for 10 seconds and then slowly return to the upright position.
- Alternate hands and bend to the left side.

MODIFICATIONS

It is acceptable to lean against a wall for better standing balance. Also, this exercise may be done from a seated position.



Ellis and Mannino use a wall for support to maintain standing balance.

EXERCISE 12. SHOULDER/ARM STRETCH

PURPOSE

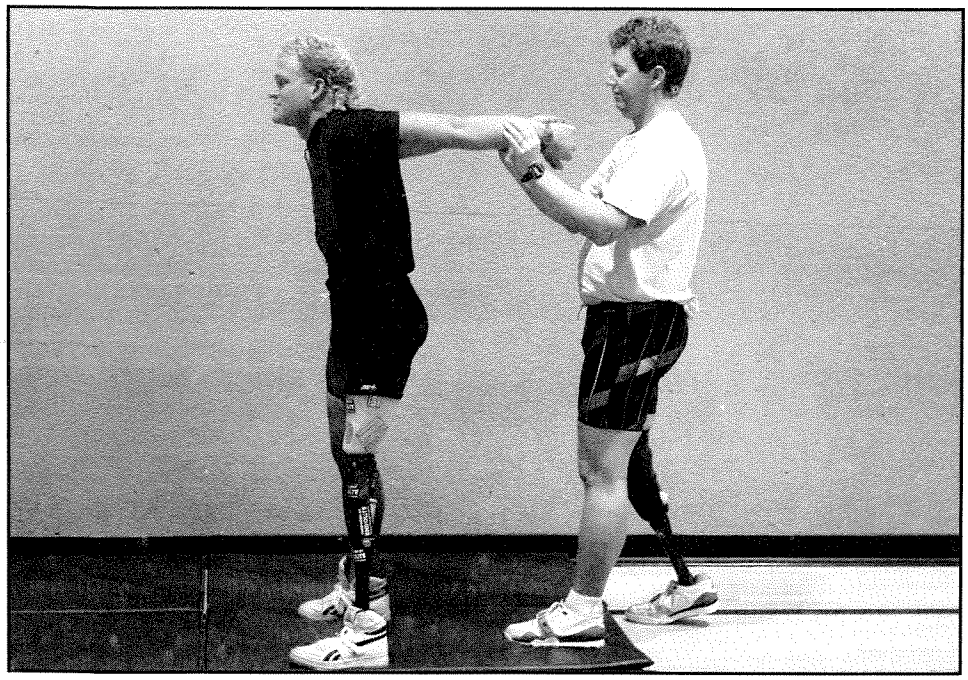
Warm-up and cool-down for the shoulders, arms, chest, and upper back muscles.

PROCEDURE

- Stand with feet comfortably apart and hands down at the sides.
- Raise both arms out from the body to shoulder height. With the arms parallel to the floor and at shoulder height, bring the fingers of both hands as close together as possible. Bring your hands together behind the back and keep the head up, the back straight, and do not bend at the knees.
- Bring both arms back out to the sides before repeating the exercise.
- This exercise may be done from a seated position.

VARIATION

When done without an assistant, this exercise requires great flexibility in order to make the hands meet behind the back. However, it is an effective stretch exercise even if the hands do not touch in the back.



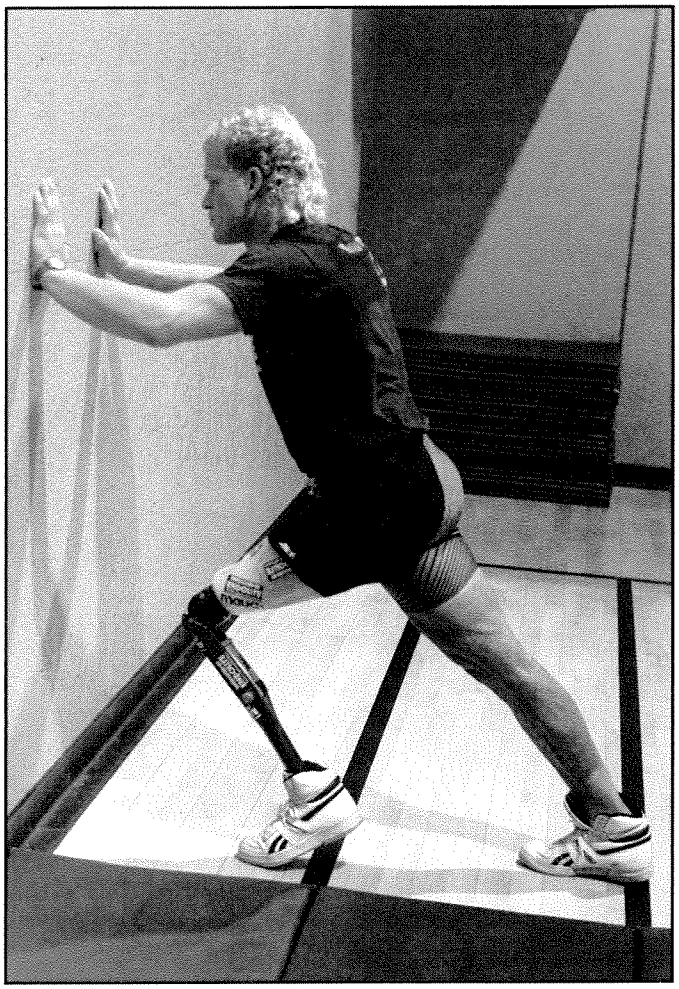
With the assistance of Richard Hughes, Greg Mannino is able to make his hands meet behind his back.

EXERCISE 13. STANDING CALF STRETCH

PURPOSE
Stretches the gastrocnemius and soleus muscles.

PROCEDURE
- Stand about 3 feet away from the wall. Step forward with one foot but keep the knee of the back leg straight.
- Lean forward as far as is comfortable, trying to touch the chest to the wall. Keep the heel of the back foot on the floor. Hold the position for about 15 seconds.
- As flexibility is developed, step further away from the wall to increase the stretch.

VARIATION
To stretch the lower calf and Achilles tendon, bend the knee of the back leg during the lean forward. Be certain to keep the heel of the back leg on the floor.



Greg Mannino uses a wall for support while doing this stretch. An exercise bar may also be used.

EXERCISE 14. STANDING TOE TOUCH

PURPOSE

Improve balance and develop flexibility in the hamstring muscles.

MODIFICATIONS

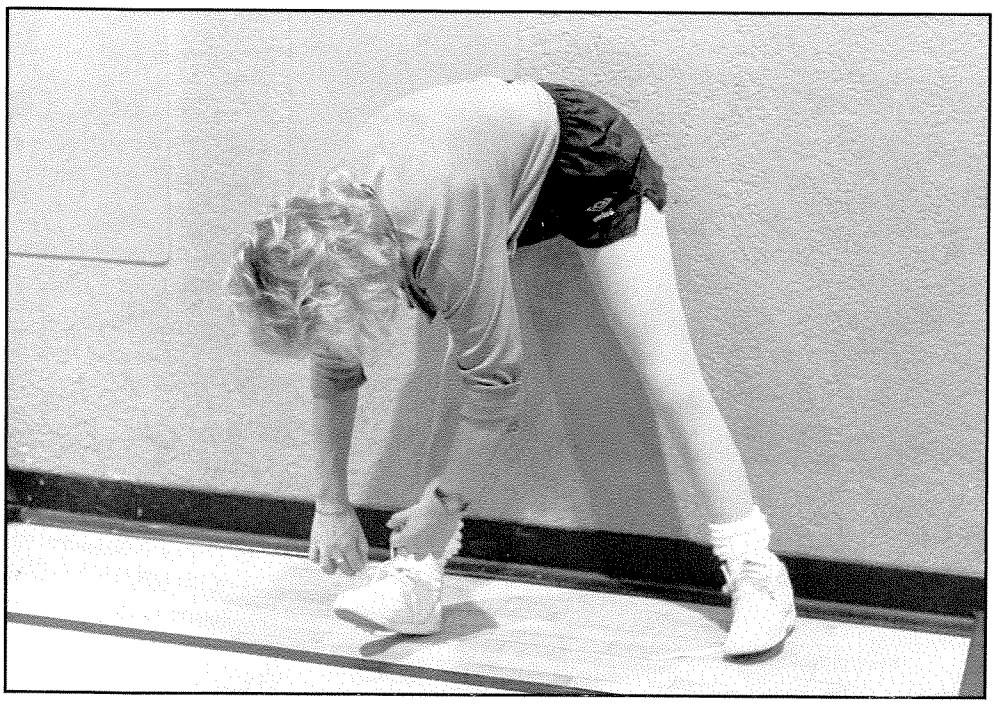
If needed, use a wall for support and balance. The anterior trim lines of the AK socket may restrict range of motion. They can be lowered or a flexible brim socket can be used.

PROCEDURE

This exercise may be done with the knees slightly bent or with the legs held straight for greater stretch of the hamstring muscles. Three variations are shown.

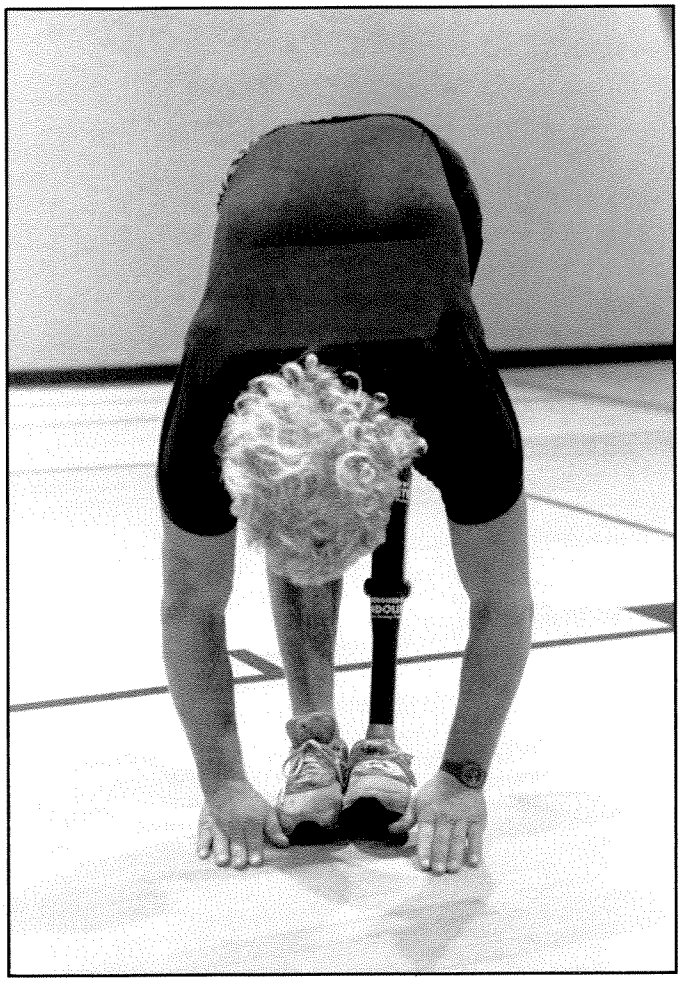
VARIATION 1

- As shown below, bend from the waist as if to touch one toe. It may not be possible without practice, but reach as far as is comfortable.
- Hold the position for a few seconds and round the back to help relax the muscles of the lower back if necessary.
- Return to an upright position before alternating sides.



Samantha Ellis uses a wall to help maintain balance.

CAUTION
The stretch should be performed in a smooth manner. Do not bounce.



Greg Mannino demonstrates good flexibility.

VARIATION 2

- Bend straight forward from the waist.
- Try to touch the tips of the toes or the floor with the fingers or the palms of both hands. This may not be possible without practice. Hold the position for 10-20 seconds, rounding the back to relax the lower back muscles.
- Return to an upright position before alternating sides.

VARIATION 3

- Cross one leg over the other and try to touch the toes or the floor. When doing toe touches this way, use the first stretch to go as far as you are comfortable, then hold for 10-20 seconds.
- During the next stretch, go a little further. Hold for 10-20 seconds.

The cross-legged position of Variation 3 adds extra stretch on the hamstring muscles of the rear leg.

EXERCISE 15. SEATED TOE TOUCH

For some with a lower limb amputation (especially above-knee), seated toe touches may be easier to perform than standing toe touches because they do not require maintaining balance.

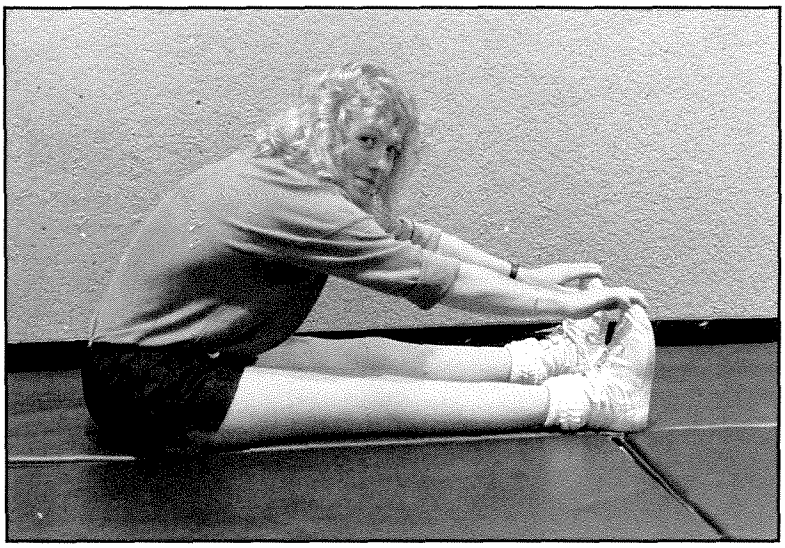
PURPOSE

Stretches the hamstring muscles.

PROCEDURE

VARIATION 1

- Sit with back and legs straight and legs close together.
- Bend from the waist and try to touch both toes with the fingers of both hands. Hold the position for a few seconds, allowing the back muscles to relax.
- Slowly return to the starting position and repeat as desired. Keep the head up; this will help keep your back straight.



Samantha Ellis touches her toes with legs together.

MODIFICATIONS

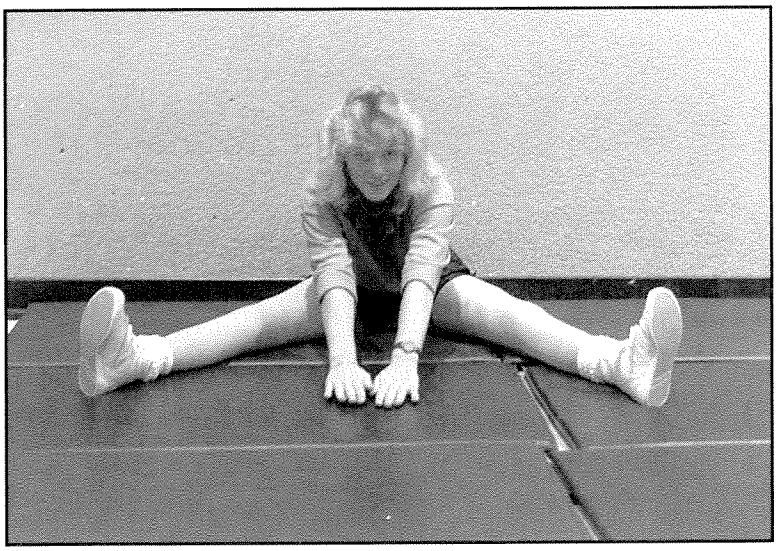
— The stretches can be combined and done in a forward-side-side manner as seen in Variations 2 and 3.

— A partner can assist you in going further forward by pushing slowly from behind or pulling gently on your arms from the front.

— You can also stretch further forward by bracing your feet against a stationary object and pulling yourself forward with a rope or grabbing a fixed object.

VARIATION 2

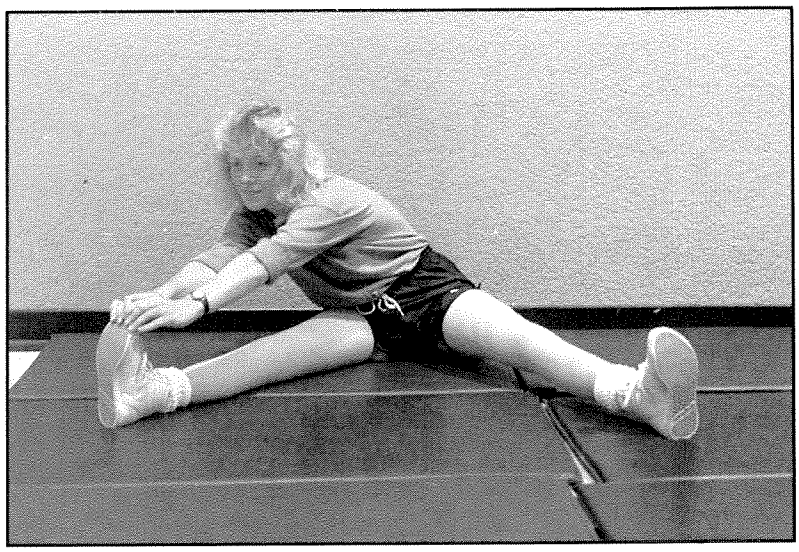
- Spread legs apart as far as is comfortable.
- Reach with both arms straight out from the body as far as possible. Hold the position for 10-30 seconds, allowing the back muscles to relax.
- Slowly return to the starting position before repeating the exercise.



Ellis stretches arms forward with legs apart.

VARIATION 3

- Keep the legs as far apart as possible.
- Reach to touch the toes of one foot with both hands. The opposite hip may pull up from the floor slightly. Hold the position for a few seconds and allow the back muscles to relax.
- Slowly return to the starting position and repeat the exercise on the other leg.
- For more stretch and greater range of motion, try to touch your forehead to your knee.



Ellis demonstrates the basic stretch.

EXERCISE 16. HURDLER'S STRETCH

PURPOSE

Stretches the hamstring muscles.

PROCEDURE

- Sit on the floor with legs spread apart. Keep one leg straight and flex the other one at the knee. (The flexed position may be difficult at first.)
- Lean forward to touch the toes on the outstretched leg. Keep the head up and back straight, bending only at the waist.
- Do not bounce, but stretch gradually, holding the furthest position for at least 20 seconds.
- Stretch a little further on each repetition.
- Avoid stressing the medial ligaments of the bent leg by proper positioning.

MODIFICATIONS

AK flexible brim

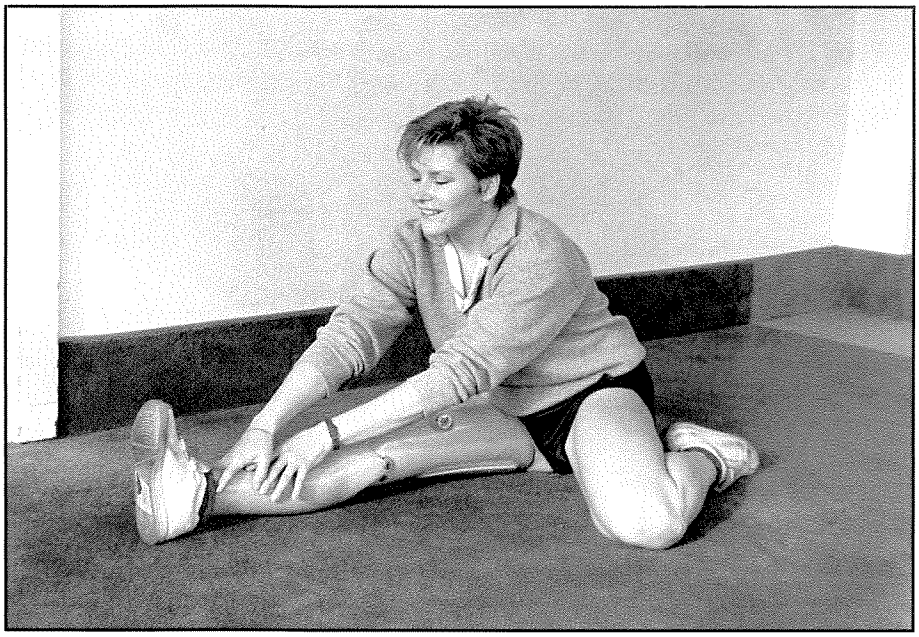
A person with an above-knee amputation may benefit from a flexible brim socket in stretching on the prosthetic side with the leg extended. If flexing the AK prosthesis at the knee is too difficult, do only the Seated Toe Touches to stretch the hamstrings with the prosthesis straight (Exercise 15).

BK suspension sleeve

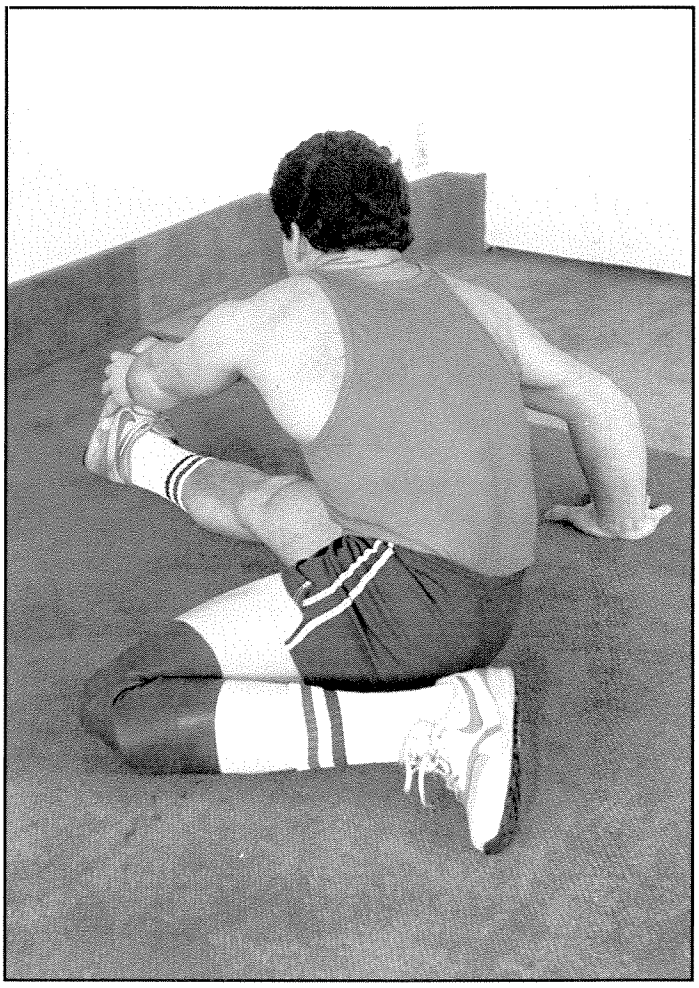
When the BK prosthetic side is extended, a cuff strap suspension may prevent a full stretch by holding the knee in flexion. Using a suspension sleeve will allow the knee to achieve a full range of motion. When flexing the BK prosthesis, the ActivSleeve suspension sleeve worn by Albert Rappoport allows the residual limb to pull out of the socket, relieving any hamstring impingement.

Lowered BK trim line

The degree of flexibility on the BK prosthetic side will depend on the height of the trim lines. While lowered medial and lateral trim lines are very helpful, lowering the posterior trim lines will best improve knee flexion.



Linda Pedersen demonstrates the Hurdler's Stretch to stretch the hamstrings of her residual limb.



Albert Rappoport stretches the hamstrings of his sound leg.

EXERCISE 17. ANTERIOR THIGH STRETCH

PURPOSE

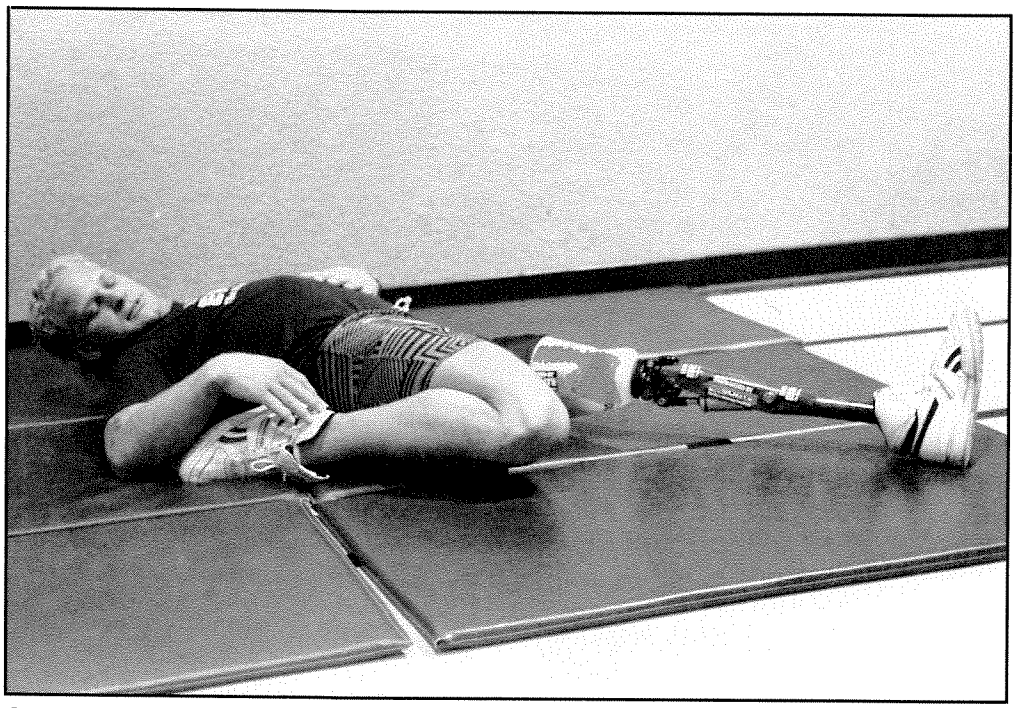
Stretches the quadriceps and nearby iliopsoas muscles.

PROCEDURE

- Lie face-up on the floor. Flex one knee while keeping the other leg straight out on the floor.
- The flexed knee will be up from the floor and the back somewhat arched. The foot may be held, as shown by Greg Mannino.
- Try to get the knee down to the floor and the back flat. Go only as far as comfortable. Hold for about 15 to 20 seconds.
- Relax before alternating sides.
- Stretching the residual limb with a flexed knee it possible for those with a BK amputation but not with an AK amputation. (Exercise 16 discusses alternatives for hamstrings.)

CAUTION

Do not stretch the quadriceps like this if you have knee problems. As an alternative, use the Standing Quadriceps Stretch (Exercise 18).



Greg Mannino stretches the hamstring muscles in getting his knee to touch the floor while holding his foot in place.

EXERCISE 18. STANDING QUADRICEPS STRETCH

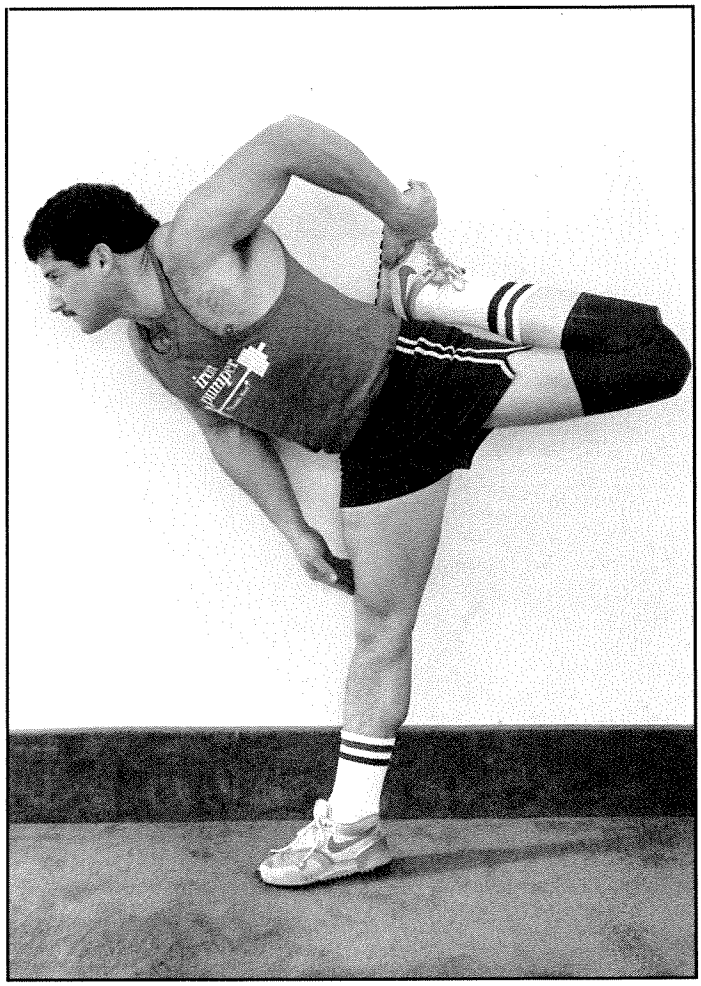
PURPOSE
Stretches the quadriceps muscle.

PROCEDURE
- Using an exercise bar or a wall for support, bend one leg back and up.
- Grab the ankle of the leg and pull it tight against the buttocks, keeping the back straight.
- Hold for about 15 to 20 seconds and release the leg to a standing position.
- Alternate sides and repeat.

VARIATION
To stretch the prosthetic side, bend as demonstrated by Albert Rappoport and pull the upper thigh until parallel to the floor. If you can keep your back in an upright position, it is preferable as you advance. The ActivSleeve suspension sleeve allows for full flexibility. The residual limb can actually pull out of the socket and slip right back into the prosthesis after the stretch because this sleeve stays in place on the thigh.

CAUTION

Recommended only for BK-level exercisers. AK-level exercisers should use the Anterior Thigh Stretch for the sound limb only (Exercise 17).



Albert Rappoport demonstrates excellent balance and form.

EXERCISE 19. DOUBLE QUADRICEPS STRETCH

PURPOSE

Stretches the quadriceps muscles.

PROCEDURE

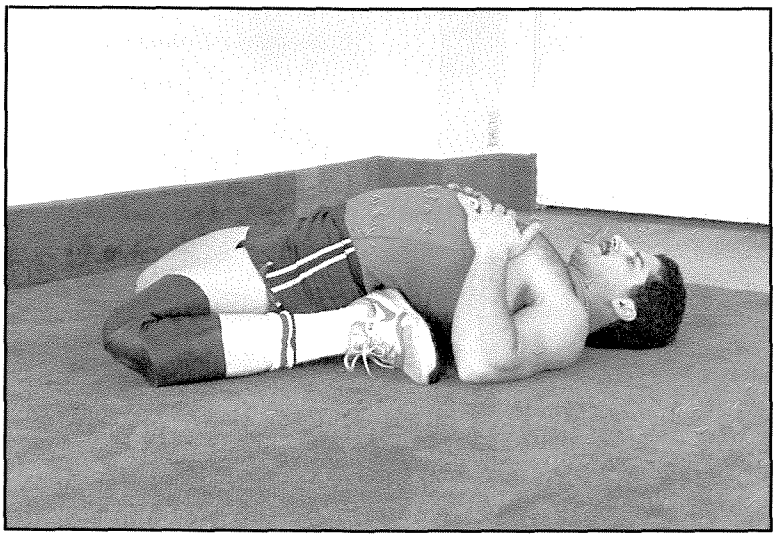
- Kneel down on both knees and sit down on your legs.
- Move your legs outside the width of the hips and turn the prosthetic foot outward while keeping the toes of the sound foot straight back.
- Slowly lean backward, moving your hands on the floor for support and to control the movement.
- Allow the residual limb to slide out of the socket as necessary.
- Lean back as far as is comfortable. Hold for 20 seconds and then return to the kneeling position. Try to lower the body a bit farther back each time.
- The goal is to lean back until the shoulders are on the floor, as shown in the photo, but do not overstretch at first.

MODIFICATIONS

— To relieve stress on the knees when in the supine position of the exercise, move them closer to the midline of the body. The sound side foot should be pointed straight back. The prosthetic foot cannot bend straight back but can be positioned to the side as pictured.

— The ActivSleeve suspension sleeve allows the knee to pull out of the prosthesis and then go back into the socket without special adjustment.

— The posterior trim line may be normal height, equal to the patellar bar, but can be modified to a lower position on those with longer residual limbs without causing any problems while walking. Medial/lateral trim lines are lowered.



Albert Rappoport demonstrates this difficult and advanced stretch.

CAUTION

This is a very demanding stretch exercise and recommended only for those with well-developed flexibility. For best results, BK-level exercisers should use the ActivSleeve suspension sleeve. This stretch is not recommended for persons with chronic knee problems or back problems.

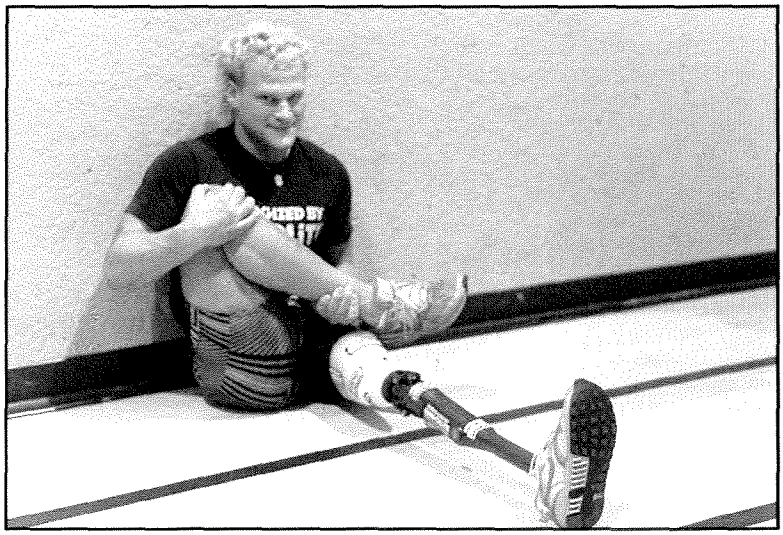
EXERCISE 20. SEATED HIP AND UPPER HAMSTRING STRETCH

PURPOSE
Stretches the gluteus maximus and other hip muscles and hamstrings.

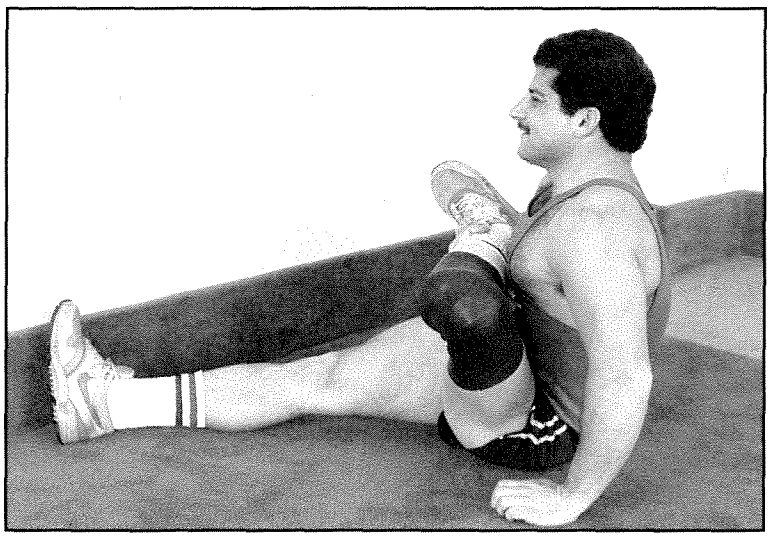
PROCEDURE
- Sit on the floor with your back against a wall.
- Keeping one leg straight out in front, flex the other knee and gently pull the entire leg toward the chest until tension is felt at the back of the upper leg. Be sure the leg is pulled to the chest as one unit, from the ankle and knee, so that undue stress is not placed on the knee.
- Hold the stretch for 20 seconds before slowly putting the leg flat on the floor again. Try to pull the leg up a bit further with each repetition.

CAUTION

Socket impingement and suspension may restrict completion of this exercise for the AK prosthetic side.



Greg Mannino demonstrates this exercise by balancing against the wall for support and using two hands to make the stretch complete. He holds his leg on the outside of the ankle with the one hand while the other hand supports the bent knee.



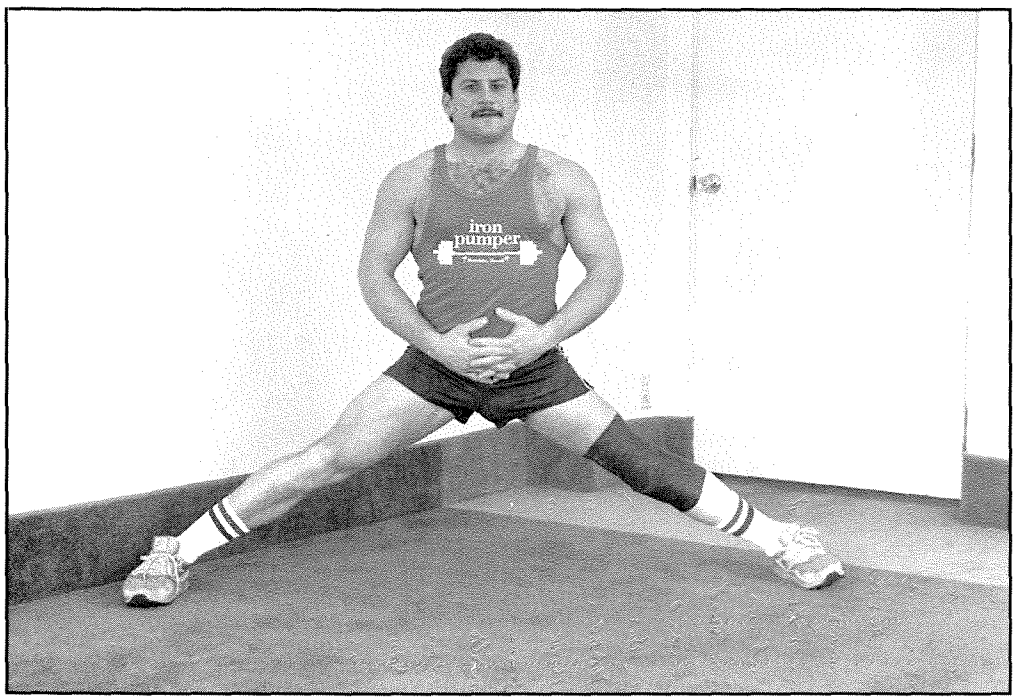
Albert Rappoport demonstrates a variation of this exercise. He balances his body with one arm while lifting his prosthetic leg for the stretch. This position may be used for both legs. The above stretch using two hands is preferable, but it there is no wall or back support available, try this technique.

EXERCISE 21. STANDING SPLIT

PURPOSE
Stretches the inner thigh and groin.

PROCEDURE
- Stand with your legs slightly apart on a non-slip surface or lie flat in the supine position.
- Work your legs apart as far as you are able, moving them out one at a time in line with your hips. Keep the back and legs straight, if possible.
- Hold the stretch for 20-30 seconds and slowly return to the starting position.
- Hands may be positioned on the knees to gain stability and push legs outward.

VARIATION
Beginners may need to bend forward and balance themselves by holding on to a railing or other fixed object.



Albert Rappoport demonstrates the exercise wearing an exoskeletal prosthesis, ActivSleeve suspension sleeve, and a DAS Foot, which has excellent inversion/eversion capabilities so it can remain flat on the floor.

EXERCISE 22. PRONE TRUNK EXTENSION/LOW BACK ARCH

PURPOSE

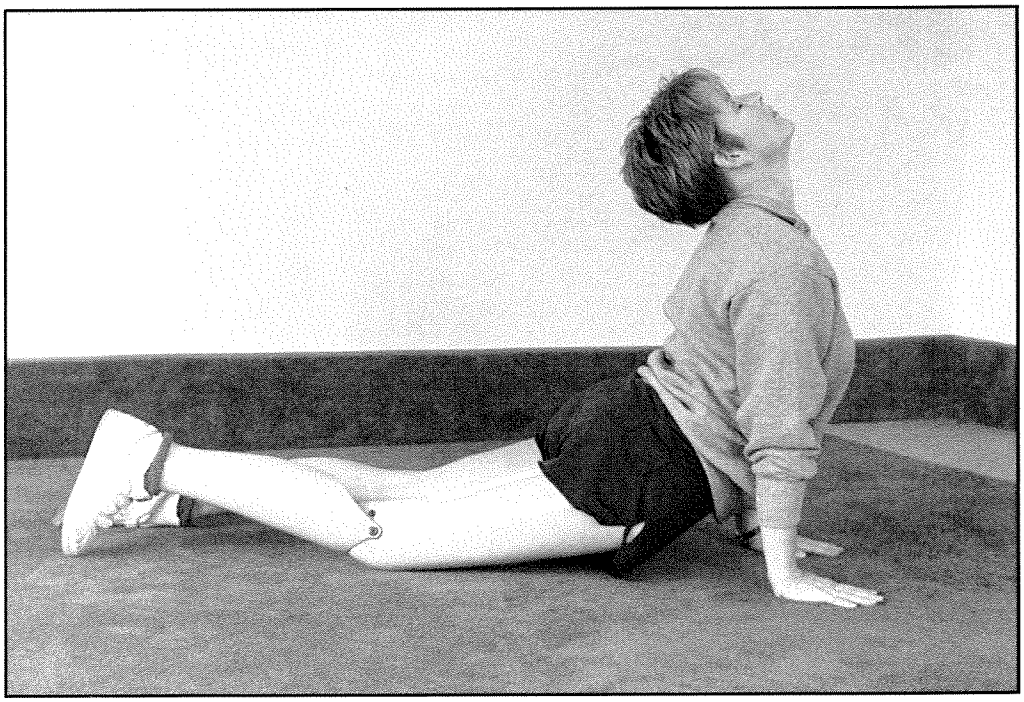
Stretches and strengthens primarily the muscles of the lower and mid-back, as well as the abdomen, chest, shoulders, and arms. Also stretches the hip flexors and abdominals.

PROCEDURE

- Lie face-down on the floor in a prone position with hands on the floor and elbows flexed at the chest level.
- Push up until the elbows are straight, as shown by Linda Pedersen.
- Keep the head up, legs on the ground, and arch the back to a comfortable position. Hold for 10-20 seconds and rest.
- Resume the stretch and try to arch the back slightly further than the last time. Hold for 30 seconds.

CAUTION

Do not arch your back so far that it is uncomfortable. This may cause back injury. When done correctly, this exercise can help to prevent back aches and pain because it strengthens the lower back muscles.



For the AK prosthesis wearer, the knee unit should be in the unlocked position while performing this exercise, as shown.

7

ARMS

Developing the muscles of the arms is an integral part of overall upper-body strength. It can be a critical factor in the rehabilitation process for many people with bilateral lower limb amputations who must transfer in and out of a wheelchair or use crutches for mobility. Arm strength is also important in many sports, for actions such as swinging a golf club or racquet and throwing a ball. Strong arm muscles are needed for most weight-lifting exercises.

The upper arms have two major muscles—biceps and triceps—and 13 smaller ones. These muscles cross the elbow joint and control elbow flexion and extension. Eight muscles contribute to flexion and seven to extension; the biceps is the most important muscle for flexion of the elbow and the triceps for extension of the elbow. Besides flexing the elbow, the biceps has two other functions: 1) supinating the forearm; and, 2) lifting the upper-arm forward. The biceps reaches its full contraction when the elbow is bent at 130 degrees and the hand is supinated.

The biceps is vital to the forehand stroke in tennis, to wrestling and rope climbing, and to other sports-related activities. The biceps works in opposition to the triceps. The athlete must be able to effectively relax the biceps while the elbow is extended by the triceps in many sport skills. The ability to control the responsiveness of muscles is what separates the athlete from the nonathlete.

When the arm is flexed to "make a muscle," many people believe that the biceps makes up the bulk of the upper arm. Actually, the triceps, with three heads—lateral, medial, and long—is the muscle that mostly determines the size of the upper arm. The major function of the triceps is to extend the elbow. The triceps is also helpful in bringing the upper arm down from an overhead position. To maintain a full contraction of the triceps, the upper arm should be behind the torso as the elbow straightens.

The lower arm, or forearm, consists of two major bones, the radius and ulna, and 19 separate muscles. These muscles control the fingers and the wrist. The majority of these muscles are contained in two masses below the elbow joint. The bulk of the muscle belly formed on the outside of the forearm are called the extensor muscles, while the inside bulk of muscles of the forearm are called flexor muscles. The complex muscle structure of the forearm supinates the hand, pronates the hand, and is involved in gripping and extending the fingers, as well as bending the hand in four separate directions. The development of arm strength from the wrists and forearms to the biceps and triceps is necessary to enhance athletic performance and guard against injury.

The exercises illustrated are examples of adaptive methods for performing standard exercises that strengthen the arms and upper body. In some cases, prostheses provide necessary support in the movements required for the exercise.

ARM EXERCISE ROUTINE

Muscle	Exercise	Title
Triceps	23	Standing Triceps Press-down
Triceps	24	Standing Dumbbell Triceps Curl
Elbow Flexor	25	Reverse Curl
Triceps	26	Supine Two-Dumbbell Triceps Curl
Wrist Flexor/Extensor	27	Wrist Curl
Elbow Flexor	28	Seated Arm Curl

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

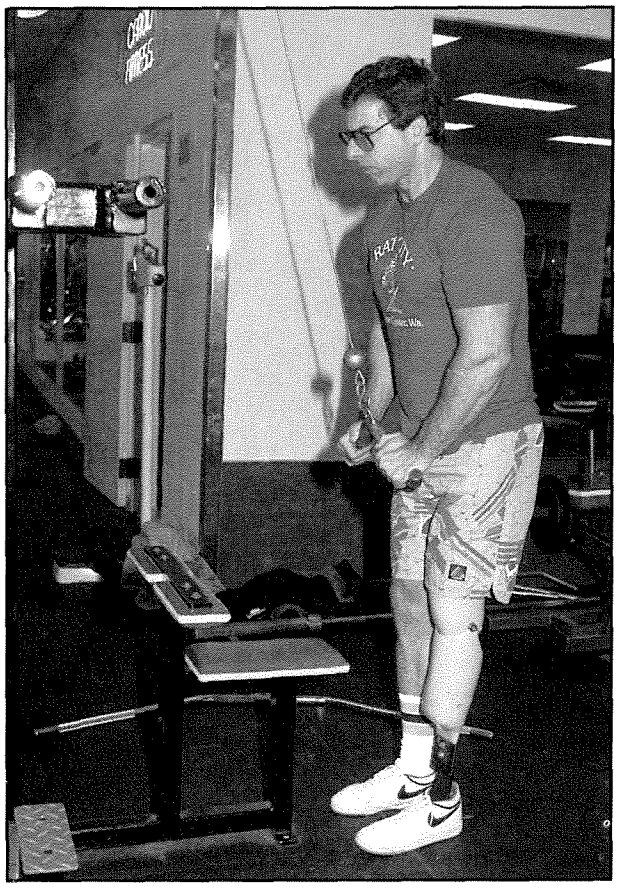
EXERCISE 23. STANDING TRICEPS PRESS-DOWN

PURPOSE
Develops the triceps.

PROCEDURE
- Stand erect with a comfortable and stable stance. Grip the bar with the palms facing down.
- Start with your forearms and biceps touching each other and palms facing forward. Keep the elbows against the side of the body and press the bar down until the arms are extended.
- Keep body motions to a minimum in order to best isolate the triceps. (It is acceptable to lean forward while pushing down the weight on the last few repetitions as you become tired.)
- Exhale as you push down and inhale as you slowly raise the weight back up in a controlled manner.

MODIFICATIONS
Various hand attachments may be interchanged with the angled bar pictured. Straight bars, rope, or leather straps may also be substituted.

SKILL LEVEL
Intermediate.



Mike Nitz demonstrates the Triceps Press-down. He wears a Narrow ML flexible brim above-knee socket with the Mauch SNS Knee Unit and Flex-Foot.

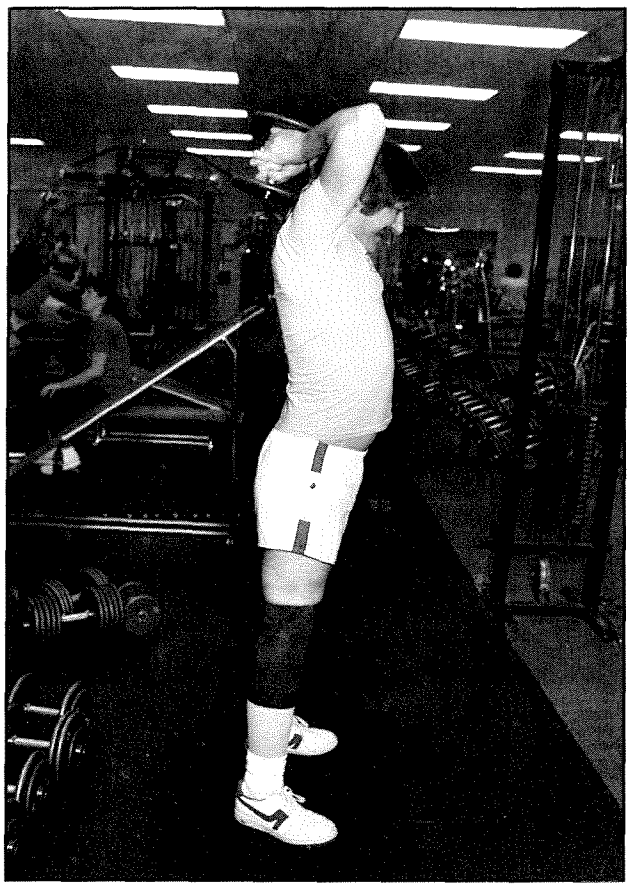
EXERCISE 24. STANDING DUMBBELL TRICEPS CURL

PURPOSE
Develops the triceps muscles.

PROCEDURE
- Feet should be positioned slightly wider than shoulder-width to give stability, so you will not fall backward when raising the weight behind the head.
- Grip the dumbbell with both hands and raise it above the head until the arms are fully extended.
- Carefully lower the dumbbell behind the head until the biceps and forearms touch. Try to keep your back straight and face straight ahead for best form.
- Inhale when lowering the weight and exhale when raising it above the head.

MODIFICATIONS
— Stable alignment of prostheses is required for this exercise, particularly for the person with bilateral amputation. If balance when standing is a problem, do this exercise sitting down.
— The dumbbell can be held in several different ways. As shown, one hand is placed on top of the other with a closed grip. Hands can be alternated so a different hand is on top for each set.
— Another method is to have the palms of both hands resting underneath the top plate, with the thumbs wrapped around the handles.

SKILL LEVEL
Intermediate.



John Everett demonstrates the standing position for the Triceps Curl. He is holding one dumbbell to provide resistance for developing strength.

EXERCISE 25. REVERSE CURL

PURPOSE

Develops the elbow flexors and the muscles of the forearm.

PROCEDURE

- Begin by bending at the knees and waist, and roll the barbell as close to your toes as possible. Grasp the bar with your palms facing you or the floor, positioning your hands shoulder-width apart.
- Raise your body to the upright position, keeping your head up and using your legs to lift the weight up from the floor.
- In the starting position, your arms should be fully extended in front of you with your hands just outside of your hips. Your feet should be spaced about shoulder-width apart.
- Bring the bar nearly up to your chin by flexing your arms at the elbows. Lower the bar to the starting position slowly. Keep the bar as close to your body as possible during the lifting and lowering.
- It is fine if the bar touches the body, because this will help keep your form strict and prevent unwanted body motions that would detract from isolating the intended muscle. Try not to sway, swing the weights, or arch your back during the exercise.

VARIATION

For more advanced lifters, it is acceptable to sway or even swing the weights up on the last few repetitions in order to complete them. These "extra" repetitions work the biceps and forearm a bit more, allowing you to complete more repetitions than you would normally and enabling you to gain extra strength and size (this should not be done in this fashion with every set). The lifter also benefits from controlling the weights as they are lowered back to the starting position.

MODIFICATION

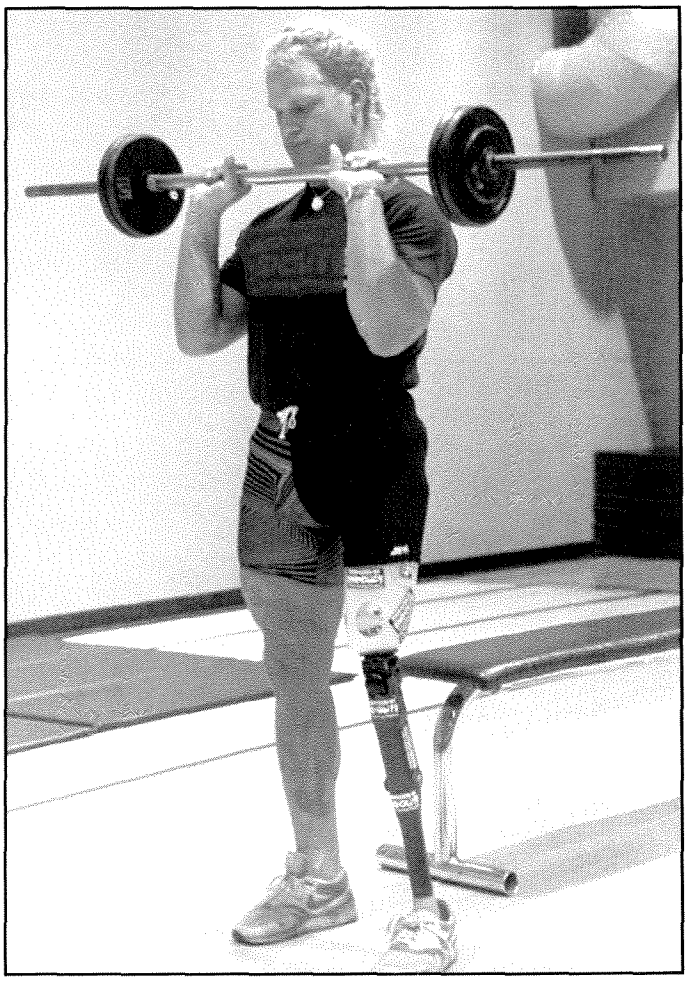
You may lean your back against a wall to limit swaying, which will increase stability while standing.

SKILL LEVEL

Intermediate.

Mannino demonstrates the top position of the Reverse Curl.

Greg Mannino works through the mid-position of the Reverse Curl.



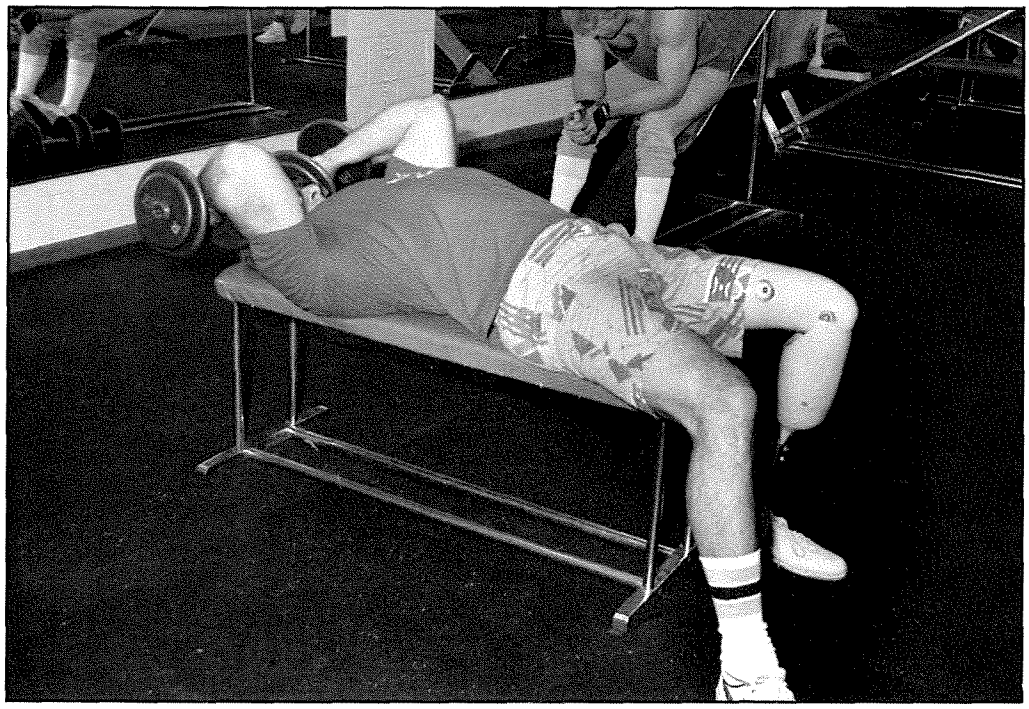
EXERCISE 26. SUPINE TWO-DUMBBELL TRICEPS CURL

PURPOSE
Develops the triceps muscles.

PROCEDURE
- Lie flat on a bench and bring both dumbbells up in line with the shoulders while extending the arms. Keep the upper portion of the arms vertical and slowly lower the dumbbells behind the shoulders until the forearms touch the biceps.
- Raise the weight straight up in line with the shoulders while extending the arms. Keep the upper portion of the arms vertical.
- Lower the weight behind the shoulders and inhale. Raise the weight back up while extending the arms and exhaling.

MODIFICATIONS
Wear the prosthesis for support and balance. If the prosthesis is not worn to support the body, a person with bilateral amputation may risk falling off the bench as the weight is brought behind the head.

SKILL LEVEL
Advanced.



Mike Nitz demonstrates a Two-Dumbbell Triceps Curl from a supine position.

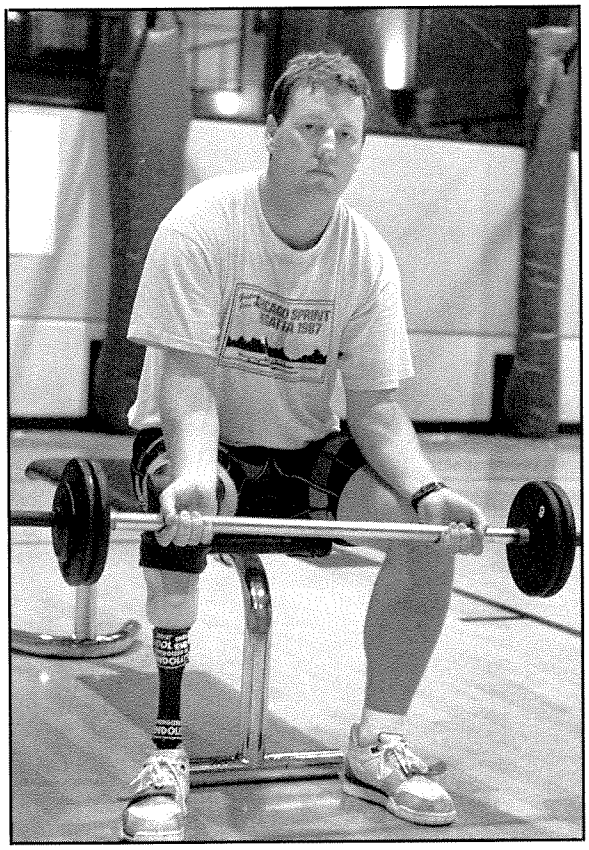
EXERCISE 27. WRIST CURL

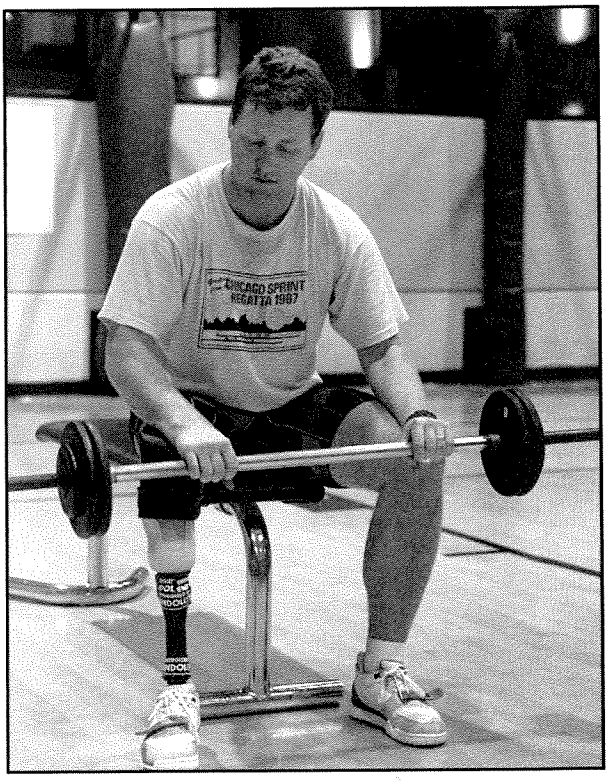
PURPOSE
Develops strength in the wrist flexor and extensor muscles.

PROCEDURE
- Sit on the edge of a bench. Grasp a barbell with your hands about shoulder-width apart.
- Rest your forearms on your upper thighs, placing your wrists over your knees.
- Lower the barbell as far from your knees as it will go. Then bring it up as high as possible without raising your forearms off your thighs.
- Alternate the grip: palms facing up to work the inside forearm (wrist flexor) muscles; palms facing down to work the outside forearm (wrist extensor) muscles.

SKILL LEVEL
Beginner.

Richard Hughes demonstrates the palms-up grip for wrist flexion to develop the inside muscles of the forearm.





Hughes demonstrates the palms-down grip for wrist extension to develop the outside muscles of the forearm.

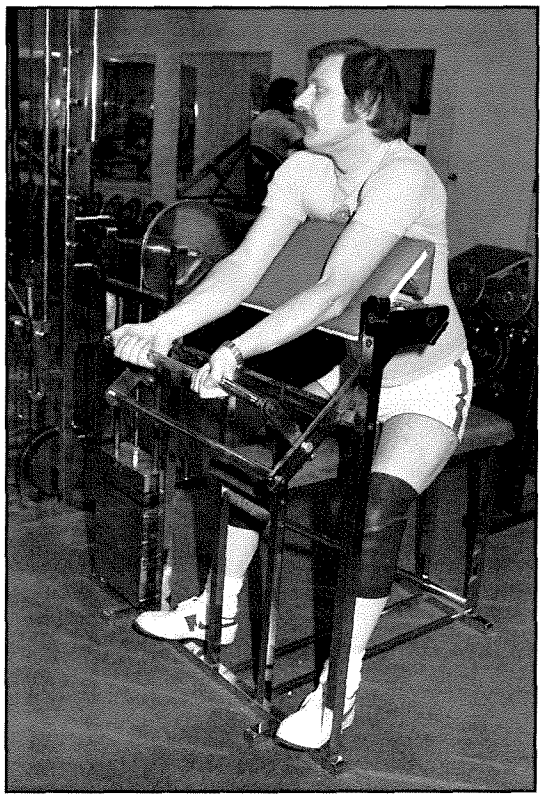
EXERCISE 28. SEATED ARM CURL

PURPOSE
Develops the elbow flexor muscles.

PROCEDURE
- Be sure that your feet touch the ground while seated on the Nautilus Biceps Curl Machine. Grab the bar with palms facing up and straight in line with the shoulders.
- Grab the curling bar at the second curve. Bringing the grip out wider concentrates more on the inner biceps, while narrowing the grip emphasizes the outer biceps.
- Position the elbows comfortably on the pads. Bring the arms up from the extended position, flexing them until the forearms and biceps touch each other.
- Keep the pressure on the biceps by not resting at the top or bottom positions. Adjust the range of motion as necessary so that constant tension remains on the biceps.
- Keep the elbows in position to prevent the upper arms from moving outward as the bar is curled. Inhale while lowering the weight and exhale while raising it.

MODIFICATIONS
— The Seated Arm Curl is recommended for those with lower limb loss, particularly for those with bilateral amputations. The seated position enables concentration on the muscles being worked, rather than on maintaining balance.
— A variety of standing and seated techniques exist to work the biceps using straight bars, curling bars, dumbbells and cables, benches, and machines. The various standing and seated techniques make the workout more interesting and allow the biceps muscles to be worked from different angles.

SKILL LEVEL
Intermediate.



John Everett demonstrates training the biceps from a seated position.

8

SHOULDERS

The shoulders are the key to many full-bodied movements. Skill in such sports as swimming, baseball, golf, and tennis and other racquet sports is improved with the help of strong shoulders. Shoulder strength is also essential for succeeding in wrestling and gymnastics. Even when sprinting, the shoulders play an important role in the arm swing, helping the runner build speed and rhythmic movement. Women are traditionally weaker in the shoulders than men and, therefore, shoulder exercises offer a great benefit to women who wish to develop upper-body strength.

Shoulder joint movement is produced primarily by 11 muscles. Of this group of muscles, the most important in size and shape are the deltoids. Deltoids are divided into three portions: anterior, middle, and posterior. Each portion can be worked individually to develop its particular potential strength. The anterior deltoids lift the arms forward, the middle deltoids lift the arms sideways, and the posterior deltoids lift the arms backward.

Because individual exercises can be accomplished with the use of dumbbells, symmetrical development of each portion of the deltoids can be assured. The benefits of proper deltoid development are strength, protection against shoulder injury, and a powerful upper body for participation in sports.

Shoulder exercises are often coupled with other movements that develop the muscles of the arms, pectorals of the chest, and trapezius and other muscles of the back. It is difficult to completely isolate the shoulder muscles during a workout because many other upper-body muscles must be involved to perform the exercises. Warm-up exercises specifically designed for the shoulders are vital to muscle development for weight lifters. Initial warm-ups should consist of low-impact exercises involving lifting weights and then progressing to higher loads over a period of time. Range-of-motion exercises should also be a part of the warm-up routine prior to weight lifting.

The following exercises are some examples of movements that can be used to develop the shoulder. Many alternatives exist in both standing and seated positions, using a variety of machines, barbells, and dumbbells.

SHOULDER EXERCISE ROUTINE		
Muscle	**Exercise**	**Title**
Anterior/Lateral Deltoid	29	Lateral Shoulder Raise
Posterior and Middle Deltoid/ Trapezius	30	Standing Side Deltoid Circle Raise
Serratus Anterior/Trapezius/Deltoid/ Triceps	31	Seated Overhead Military Press
Serratus Anterior/Trapezius/Deltoid/ Triceps	32	Seated Behind-the-Neck Military Press
Deltoid/Elbow Flexors and Extensors	33	Seated Alternated Dumbbell Press
Anterior and Middle Deltoid/ Trapezius	34	Upright Rowing
Posterior Deltoid/Trapezius	35	Seated Bent-over Rear Deltoid Raise

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

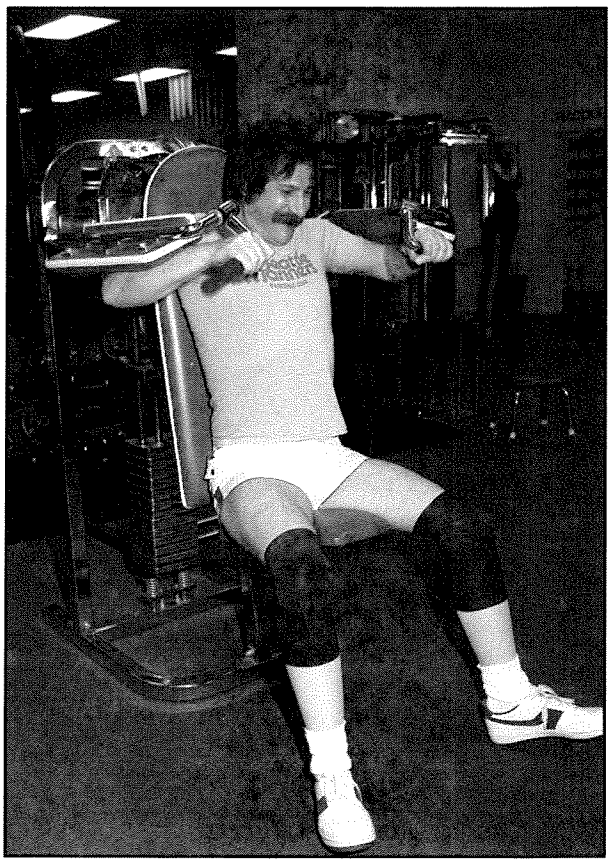
EXERCISE 29. LATERAL SHOULDER RAISE

PURPOSE
Develops the anterior and lateral portion of the deltoid muscles.

PROCEDURE
- Position the height of the seat so that the feet are firmly planted on the floor. This gives resistance against the floor and assists in balance and stability while lifting. Notice in the photo how the heel of the prosthetic foot is the main contact point. (The prosthetic foot does not plantarflex with muscular control, so it cannot be completely flat.) The seat should be adjusted so the height of the shoulder joint is even with the machine's cam, or the center axis of movement.
- Place the forearms against the pads and grip the handles, but not tightly. Start with your arms at your sides.
- Raise the arms up while pushing against the forearm pads.
- Raise the weight until the forearms are parallel to the floor or even with the top of the shoulders. Inhale while raising the weight and exhale while lowering the weight.
- Raise the weight with a count of two and lower the weight with a count of four.

MODIFICATION
The seated position allows for concentration on working the shoulders, rather than on maintaining body balance while lifting the weight.

SKILL LEVEL
Intermediate.



John Everett demonstrates the Lateral Shoulder Raise on the double shoulder machine. Machines may vary slightly among manufacturers, but the use of the apparatus is similar.

EXERCISE 30. STANDING SIDE DELTOID CIRCLE RAISE

PURPOSE

Works the posterior and middle portion of the deltoid muscle as well as the trapezius muscles and scapular external rotators (infraspinatus teres minor).

PROCEDURE

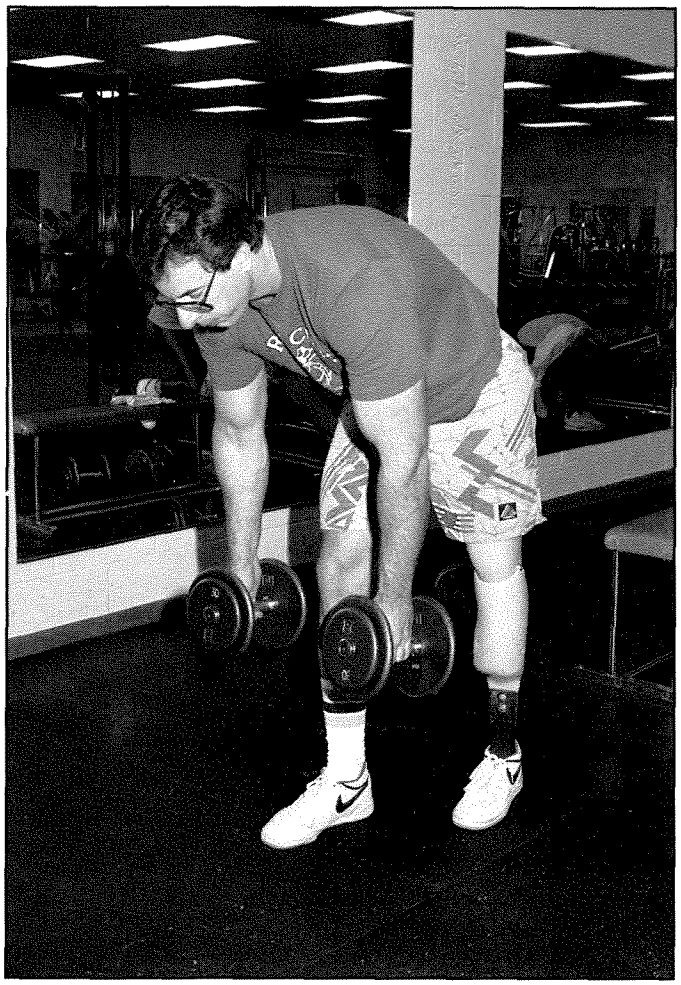
- Pick up the weights with your palms facing each other as shown in the top photo. Try to use your legs to lift the weight, rather than your back. Keep the back straight and the head up.
- Stand up straight with your feet positioned in a comfortable stance so you are well balanced and relaxed. The feet should be about shoulder-width apart; the arms should be fully extended at your sides with a dumbbell in each hand.
- Begin with the arms hanging in the starting position. Raise the dumbbells simultaneously out to the sides, bringing them up just above shoulder height, as seen in the photo. It is acceptable to flex the elbows slightly as the weights are brought up. Inhale when raising the weights and exhale when lowering the weights.
- Lower the weights using the same lateral motion with which they were raised.

MODIFICATION

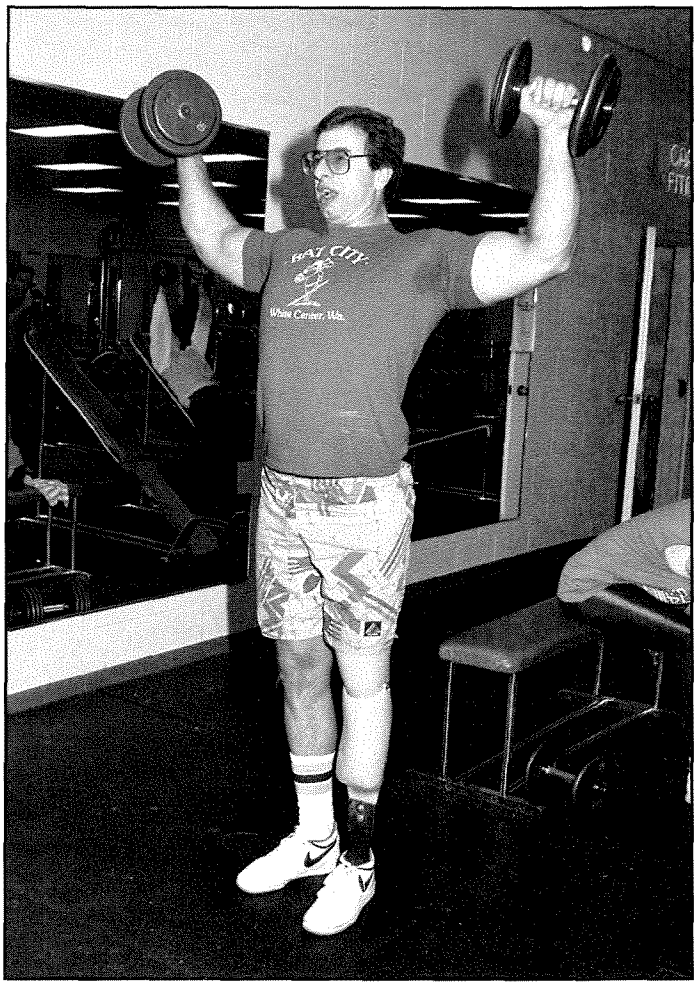
The prosthetic leg is positioned behind the sound limb when picking up the weights. This stance provides extra stability by allowing most of the weight to be taken on the sound limb.

SKILL LEVEL

Intermediate.



Mike Nitz demonstrates the correct way to pick up the weights from the ground before beginning the exercise.



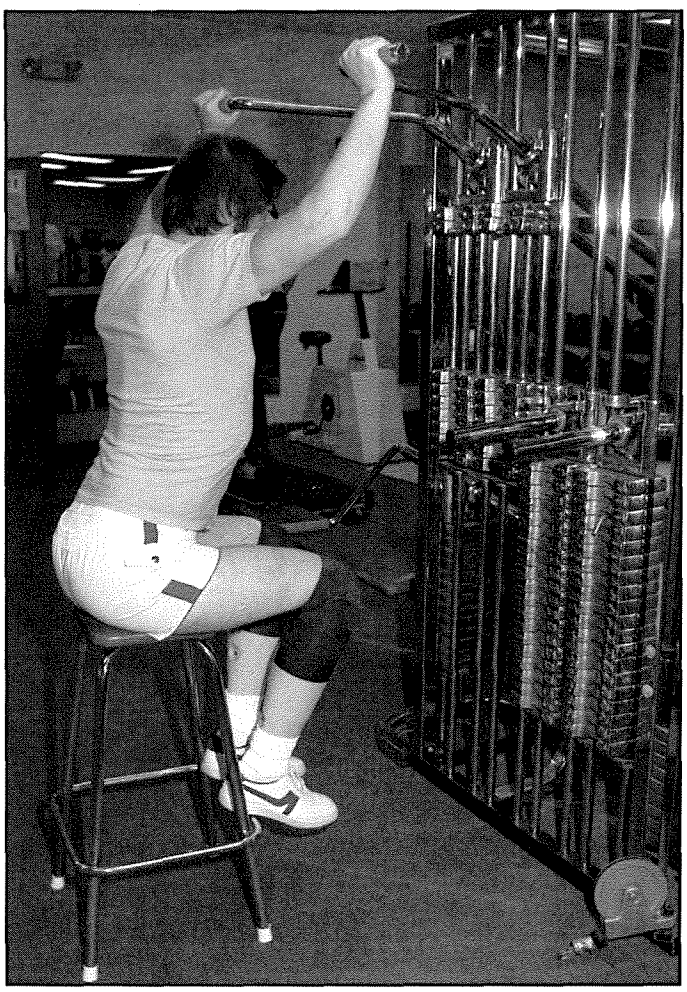
Nitz raises the weights using a semicircular motion while extending the arms until they are just above the head.

EXERCISE 31. SEATED OVERHEAD MILITARY PRESS

PURPOSE
Develops serratus anterior, trapezius, deltoids, and triceps.

PROCEDURE
- Sit on the stool and position yourself in the middle of the bars. Grab the bars with your hands evenly spaced outside the shoulders.
- Start with your biceps touching your forearms and push upward from the shoulder level until the arms are fully extended overhead.
- Keep your back straight and your head up as you lift.
- Lower the weights slowly with a count of four. Lower the hands so that they are below the ears. You may need to adjust the seat so that you can get a full range of motion going up and down.
- Inhale as you raise the weights and exhale as you lower them.

SKILL LEVEL
Intermediate.



John Everett demonstrates the Seated Overhead Military Press on the Universal machine.

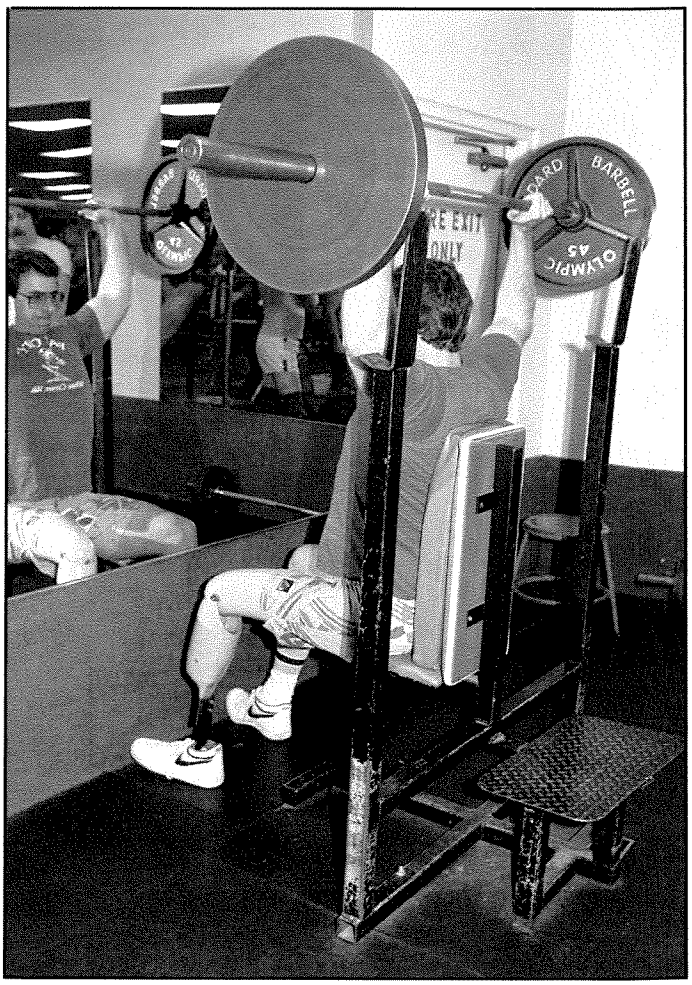
EXERCISE 32. SEATED BEHIND-THE-NECK MILITARY PRESS

PURPOSE
Develops serratus anterior, trapezius, deltoids, and triceps.

PROCEDURE
- Position the barbell on the stand and add the desired amount of weight. Make sure your feet are planted firmly on the floor.
- Sit on the bench with your back flat against it. Position your hands on the bar about 4-6 inches outside your shoulders.
- Lower the weight down to the back of the shoulders while you exhale.
- Inhale and press the barbell overhead until your arms are fully extended. Exhale as you lower the barbell back down until it reaches the shoulders.
- Lift the weight in a slow, controlled fashion and lower it in the same manner. This helps to keep tension on the muscles longer as you go through the full range of motion.
- It is acceptable to lock your elbows out for a few seconds at the overhead position before the weight is lowered.
- You can momentarily rest the weight on the shoulders as it is lowered before you lift it again for the next repetition.

SKILL LEVEL
Advanced.

CAUTION
Beginners are encouraged to use a spotter at all times during this exercise. For others, it is a good idea to have a spotter on hand to assist in case of difficulty in getting the weight off the stand, pressing the weight, or putting it back in place. (The spotter may stand on the metal step behind the bench.)



Mike Nitz demonstrates excellent form as he performs this exercise, lifting a weight of 135 pounds.

EXERCISE 33. SEATED ALTERNATED DUMBBELL PRESS

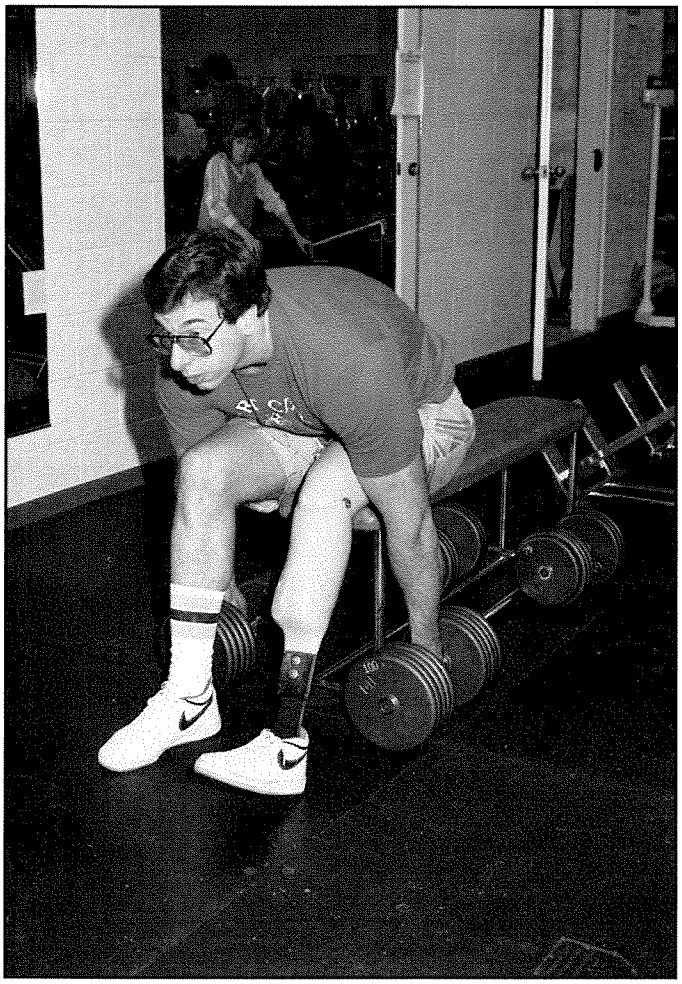
PURPOSE

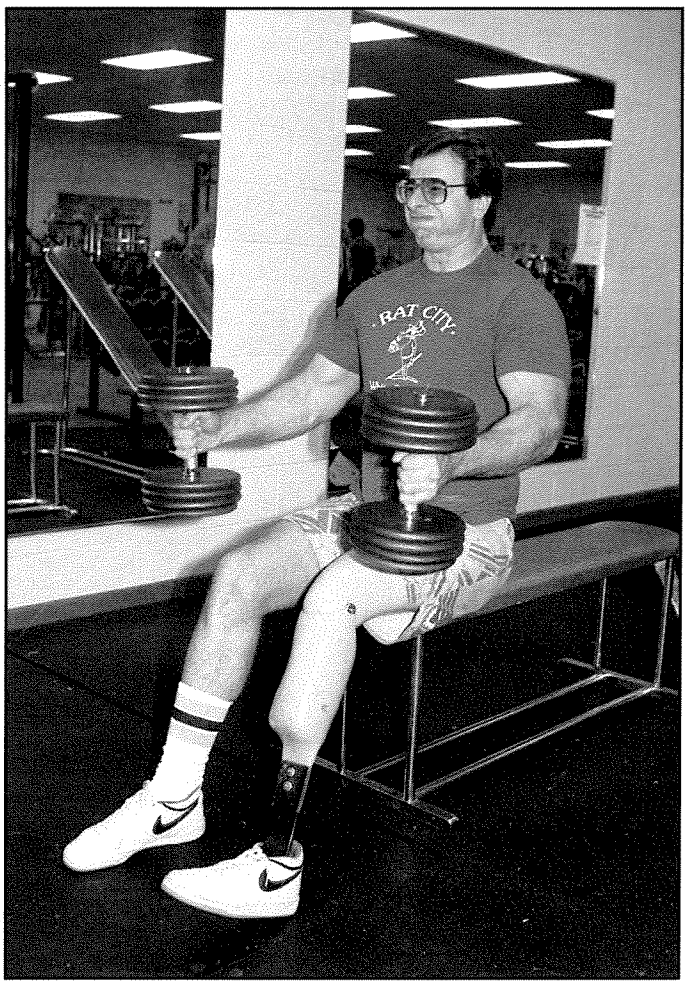
Develops deltoid muscles, elbow flexors and extensors, and scapular external rotators.

PROCEDURE

Option 1: The Clean

- Lift two dumbbells in a continuous motion, keeping the back straight and the head up, until they are at shoulder height. (This is called "cleaning the weight.")
- Position the feet firmly on the floor and push against the floor for stability. Notice that the heel of the prosthetic leg is pushing against the floor.
- Keep the elbows out to the sides and the thumbs facing each other.
- Lift to mid-chest level.





Mike Nitz demonstrates lifting dumbbells from the ground to shoulder height using one continuous motion, called a "clean." This is needed to get the weights into position in order to perform the actual lifting portion of the Dumbbell Press.

PROCEDURE

Option 2: Pressing the Weight

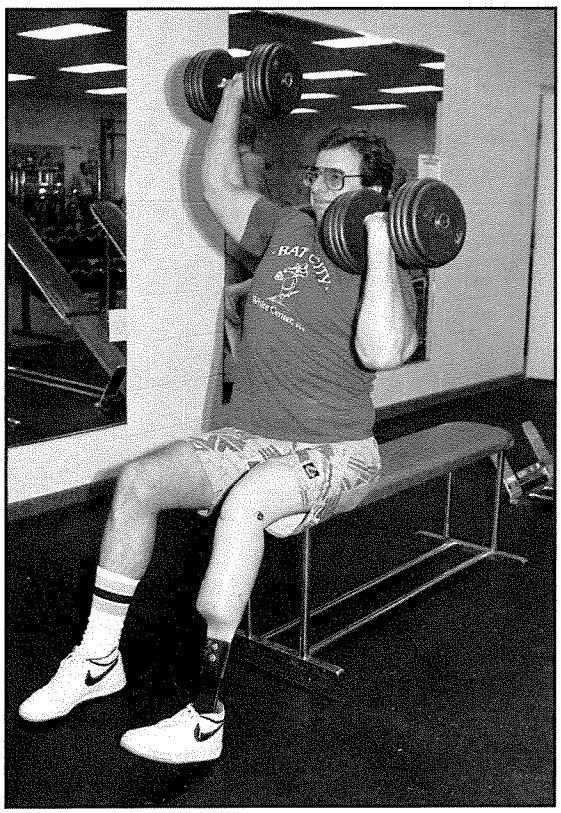
- When both weights have been brought to shoulder level, lift the weight in your right hand straight up above your head until the arm reaches full extension.
- After the full lift, lower the weight to shoulder height and lift the weight in your left hand, raising the arm to full extension.
- Continue to alternate until you have completed the desired number of repetitions.
- Bring the weights back down in a controlled manner by lowering your arms so that they hang at your sides.
- Bend at the waist until the weights are resting on the floor.

MODIFICATION

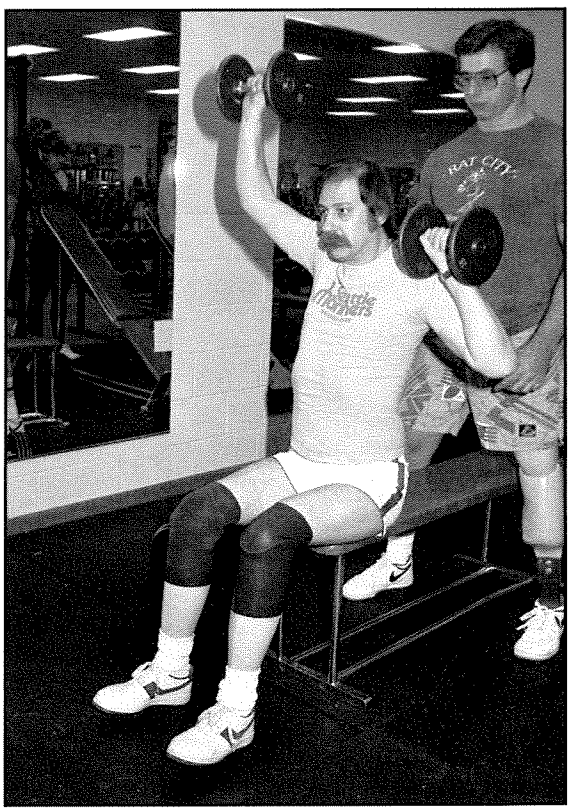
The seated position is excellent for the weight lifter with amputation, as well as the nondisabled, because it reduces excessive body movements that detract from isolating the intended shoulder muscles.

SKILL LEVEL

Intermediate.



"Pressing the weight" is demonstrated by Mike Nitz.



John Everett "pressing the weight." Note the spotter in the background.

EXERCISE 34. UPRIGHT ROWING

PURPOSE

Develops the anterior and middle deltoids and upper trapezius muscles.

PROCEDURE

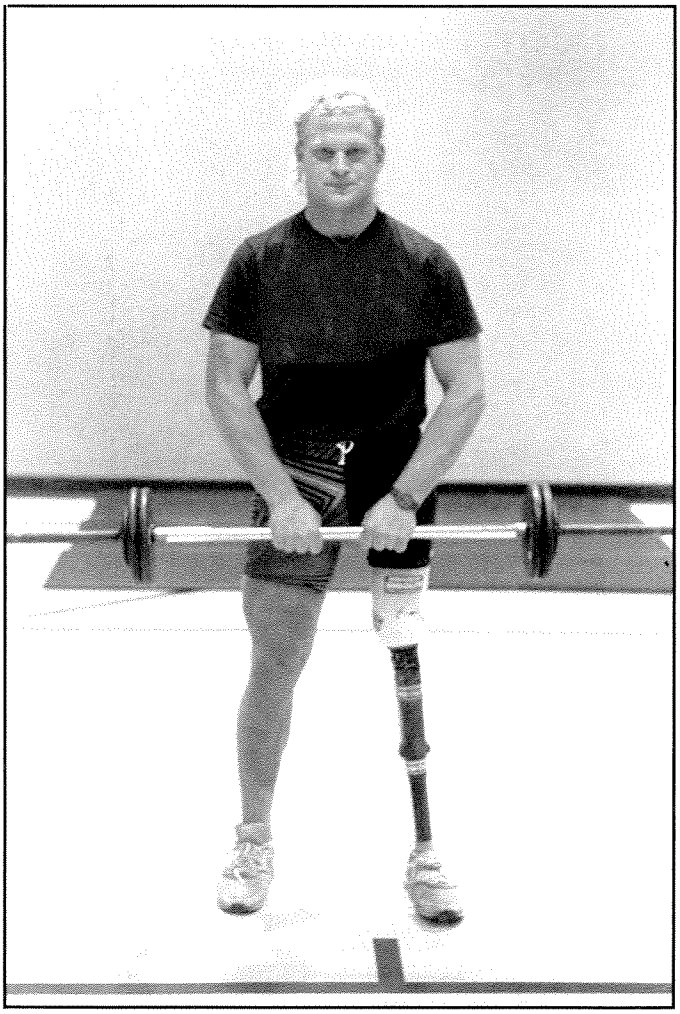
- Bend over from the knees and waist to roll the bar on the floor as close to the feet as possible. Grip the bar with your palms facing you.
- Pick up the bar and raise yourself to a standing position, using the legs more than the back to pull yourself and the weight up.
- Stand with your feet about shoulder-width apart and your arms extended in front of you, as shown in the top photo.
- Keep the barbell close to your body as you pull it straight up to chin height (or as close as you are able to raise it). Keep standing straight.
- At the top position, the elbows should be out to the sides and almost as high as the ears, as demonstrated by Greg Mannino.
- Pause momentarily at the top position before lowering the weight back down, so the arms are extended.
- Inhale while lifting the weight and exhale while lowering the weight.

SKILL LEVEL

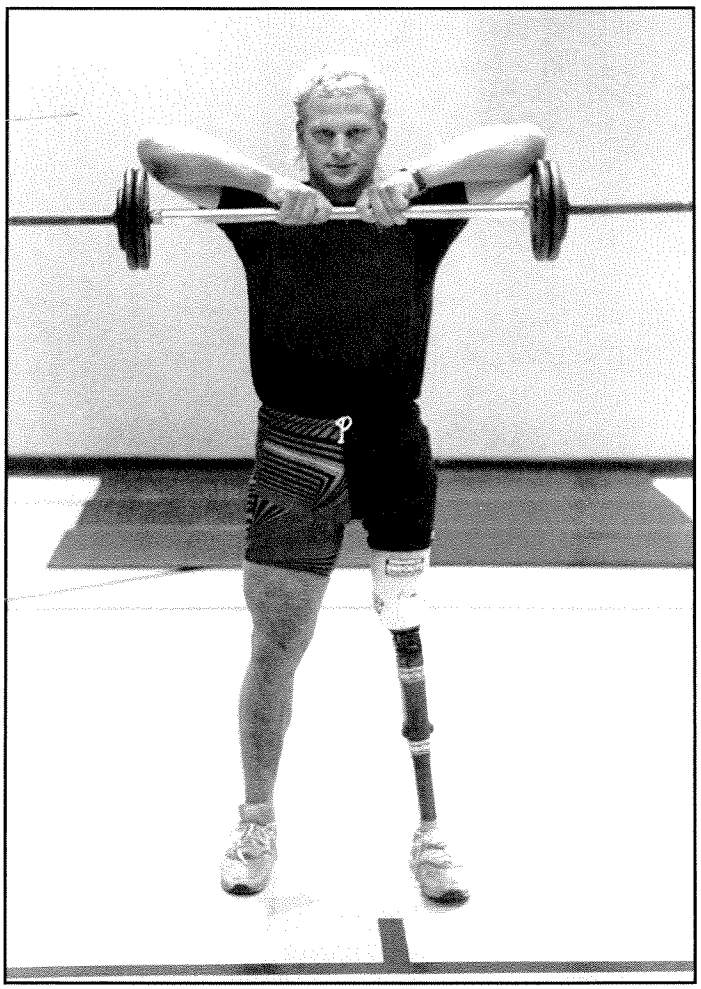
Intermediate.

NOTE

A close grip is with the hands about 6 inches apart, a medium grip is about 18 inches apart, a wide grip is about 32 inches apart. The wider the grip, the more difficult it is to perform the exercise. For some, a too-wide grip feels awkward; a narrow-to-medium grip is preferred by most and is more comfortable.



Greg Mannino demonstrates upright rowing.



EXERCISE 35. SEATED BENT-OVER REAR DELTOID RAISE

PURPOSE

Develops the posterior deltoid and trapezius muscles.

PROCEDURE

- Select two lightweight dumbbells (10 pounds or less for the beginner); place them on the floor on either side of the end of a flat bench.
- Sit at the end of the bench with your feet fairly close together and planted firmly on the floor. The dumbbells should be on either side below where you are sitting.
- Lean forward so that your chest almost touches your thighs. Keep your head facing the floor. Lift the dumbbells to the height of your ears.
- Raise the dumbbells out and upward, straightening your arms and locking the elbows.
- Lower and raise the dumbbells in a continuous semicircular motion, keeping your arms straight and elbows locked.
- Inhale as the dumbbells are raised; exhale as they are lowered.

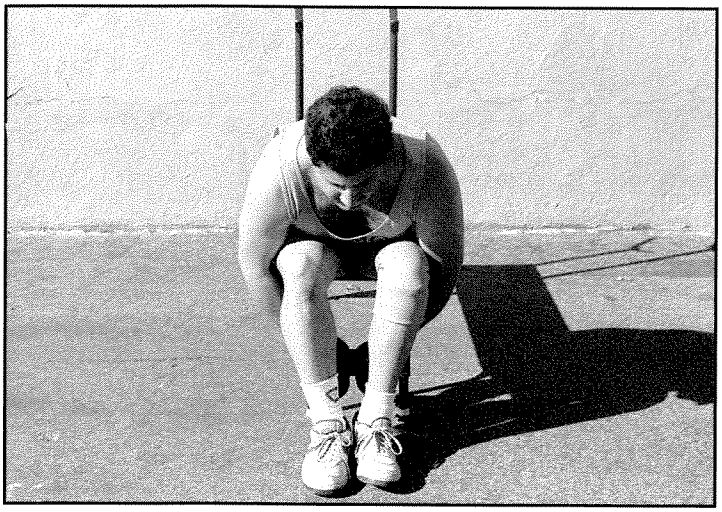
MODIFICATIONS

— There are a variety of ways to exercise the posterior deltoid muscles, some of which are from a standing position.

— The seated version demonstrated here is best for a person with lower limb amputation, since balance is not a factor. Full concentration can be placed on working the muscles.

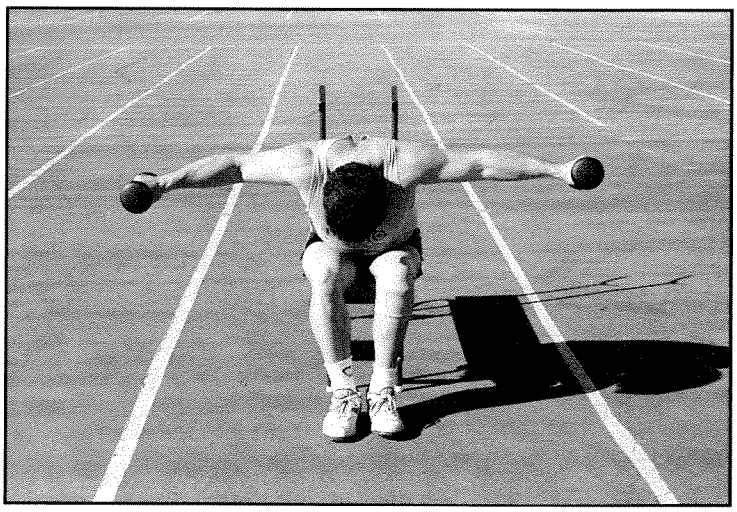
SKILL LEVEL

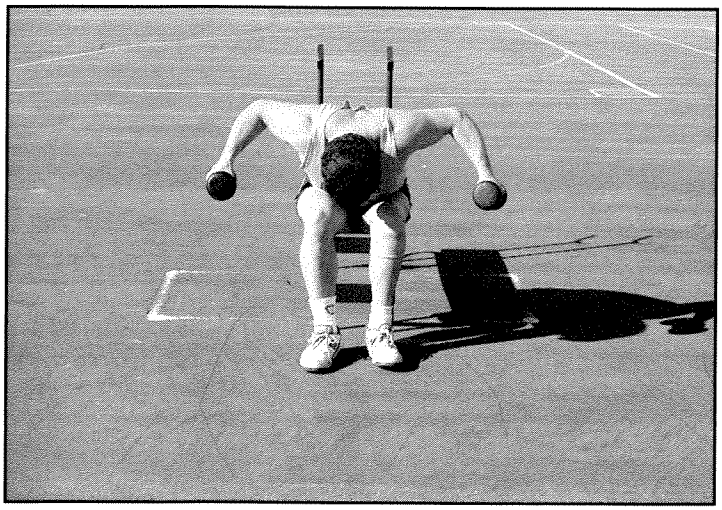
Intermediate.



Albert Rappoport demonstrates the exercise.

A variation can be done when raising the weights. Instead of keeping the arms straight as demonstrated, bend the elbows to about 90 degrees as shown. Only the upper arms are parallel to the ground. This variation allows one to lift heavier weights since the weights are not held so far out from the body. Albert Rappoport demonstrates.





Photos by GAIL UELLENDAHL

9

LEGS

People with lower limb amputation may tend to focus on developing only upper-body strength. They often do not understand the importance of developing strength in their sound leg and residual limb. Leg conditioning helps to retain symmetry of the body, improve the walking gait, and combat the natural process of atrophy that takes place in the residual limb. Weight training helps keep the muscles of the legs strong and protects the joints from injury. Strong leg muscles reduce the stress placed on the sound limb of the person with a unilateral amputation during walking, running, and sports activities.

Each person's residual limb is unique in structure. For this reason, the way one person with AK amputation accomplishes a particular exercise while wearing a prosthesis may be quite different from the way another person with AK amputation does the same exercise. Method greatly depends on the structure and length of the residual limb. However, a variety of weight training and resistant exercises are available, and one may select those which best suit the conditions of the residual limb and prosthetic fit. It is a good idea to switch exercises periodically to work the muscles at different angles.

The knee is one of the largest and most complex joint structures of the body and is surrounded by numerous tendons and ligaments. Tendons connect muscle to muscle; ligaments connect bone to bone. You cannot strengthen tendons and ligaments directly through weight training. Training the quadriceps muscles will help to strengthen the tendons and ligaments in a secondary fashion, but not directly. The stronger the muscles, the more the muscle structure can give support to the tendons and ligaments. Strength of the knee muscles and stability of the knee joint structure via its ligaments is vital to the physical abilities of individuals who wear below-knee prostheses. For those with an above-knee amputation, a strong knee on the sound leg is important in maintaining mobility and agility.

Weight training exercises that require standing may be difficult for some people with lower limb amputation because standing exercises require balance. Also, additional weight is placed on the residual limb when lifting weights. In turn, this weight is transferred through the socket. For weight lifting exercises from a standing position, extra socks may be necessary to help withstand the added strain on the residual limb. Seated leg exercises, using equipment such as Nautilus or Universal, are preferred for many individuals with lower limb amputation because they are better able to isolate the muscle group they want to work, as well as eliminate balancing problems.

The following exercises strengthen the adductor/abductor, hamstring, gluteus maximus, quadriceps, and gastrocnemius/soleus muscles. This type of program should be performed every other day on a regular basis.

LEG EXERCISE ROUTINE		
Muscle	**Exercise**	**Title**
Quadriceps/Lower Thighs	36	Single Knee Extension
Quadriceps	37	One-legged Low Wall Pulley Knee Extension
Quadriceps	38	Seated Knee Extension
Quadriceps/Thighs	39	Skier's Position
Quadriceps/Gluteus Maximus	40	Moon Bench Leg Press
Upper Thighs/Hips	41	Nautilus Double Leg Press
Quadriceps/Hip Extensors	42	Alternating Leg Press (Nautilus Duo Squat Machine)
Quadriceps	43	Half Squats
Hip Extensor/Hamstrings/ Gluteus Maximus	44	Nautilus Hip and Back Machine
Hamstrings	45	Leg Curl
Hamstrings	46	Standing One-legged Low Pulley Leg Curl
Hamstrings/Gluteus Maximus	47	Standing Pulley Hip Extension
Abductor/Adductor	48	Nautilus Hip Abduction/Adduction Machine
Abductor	49	Low Pulley Single Hip Abduction
Hip Adductors	50	Low Pulley Single Hip Adduction
Gastrocnemius	51	Weighted Standing Calf Raise
Gastrocnemius/Soleus	52	Seated One-legged Toe Raise

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

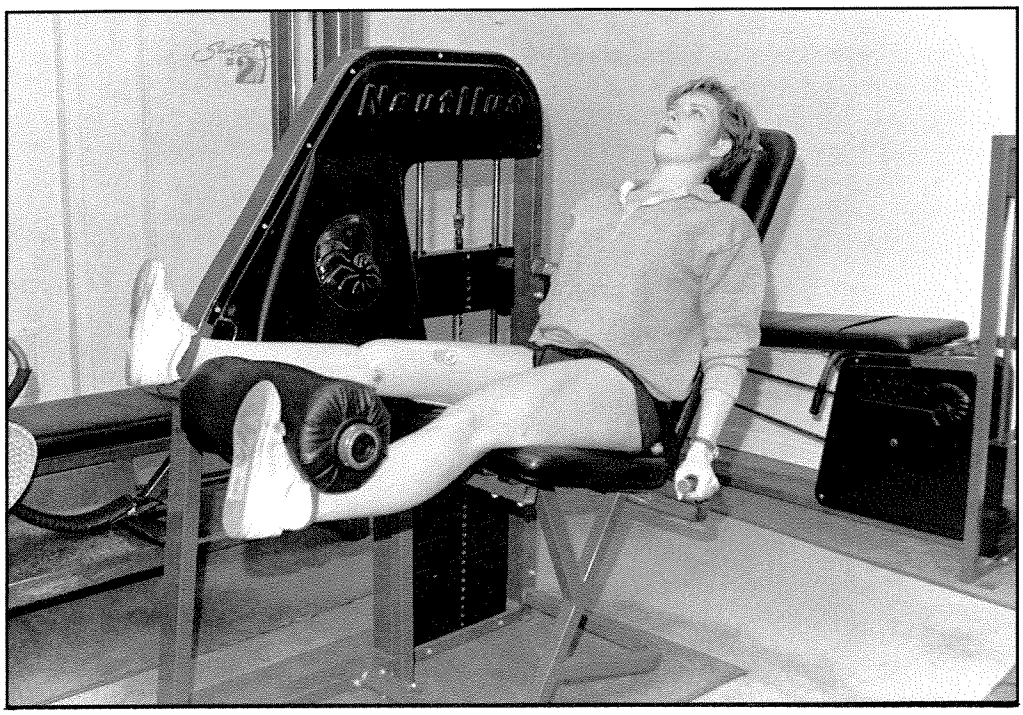
EXERCISE 36. SINGLE KNEE EXTENSION

PURPOSE
Develops the quadriceps muscles.

PROCEDURE
- Sit on the bench so that the back of the knee of the sound leg is touching the edge of the bench and the foot is on the floor.
- Place the top of the foot and ankle under and against the foot pad.
- Sit with the back pressed against the back support. Secure the seat belt and grasp the handles on the sides for support.
- Extend the knee until the leg is nearly parallel to the floor. Slowly lower your leg back to the starting position.

MODIFICATION
For those with AK amputation, the prosthetic knee may be locked in extension and the leg placed on a bench or chair off to the side, or the knee may be left in a flexed position over the edge of the bench, because the prosthetic leg cannot be used effectively in this exercise.

SKILL LEVEL
Intermediate.



Linda Pedersen demonstrates this knee extension exercise on the Nautilus equipment.

EXERCISE 37. ONE-LEGGED LOW WALL PULLEY KNEE EXTENSION

PURPOSE
Develops the quadriceps muscles.

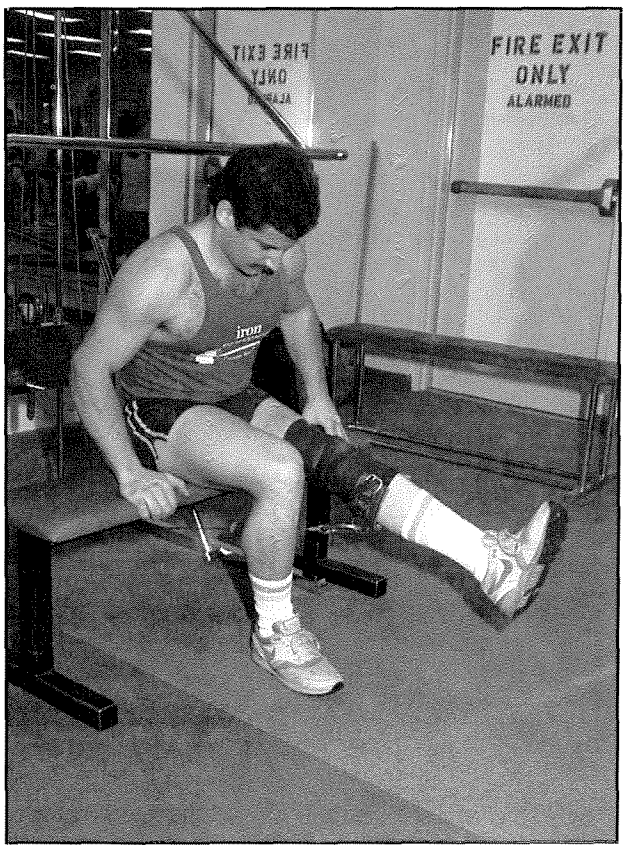
PROCEDURE
- Position a fairly tall flat bench sideways in front of the weight stack.
- To exercise the prosthetic leg, pull the cable underneath the bench and attach the cuff strap around the prosthesis in the middle of the socket. The position will vary depending on the length of residual limb and individual preference (see NOTE below).
- Start with both feet on the ground with the lower legs vertical to the floor. Adjust the position of the bench far enough away from the machine so the weights are slightly off the stack before beginning to lift the leg.
- Hold onto the bench for support and extend the prosthetic leg until it is at full extension. (Full extension may be difficult to obtain with certain prostheses that have cuff suspension or joints and lacer.)

MODIFICATION
For those with short residual limbs, moving the cuff strap proximally on the leg rather than placing it distally at the ankle should prevent anterior distal tibia pressure.

SKILL LEVEL
Intermediate.

NOTE

To obtain full extension of the knee, sleeve suspension works well for the BK prosthesis. This is a good exercise to accommodate the prosthetic limb, but when you want to train the sound side it is easier to use the conventional Leg Extension Machine seen in Exercises 36 and 38.



Albert Rappoport demonstrates leg extensions using a pulley attached to a leather cuff strap and D-Ring on his exoskeletal prosthesis.

EXERCISE 38. SEATED KNEE EXTENSION

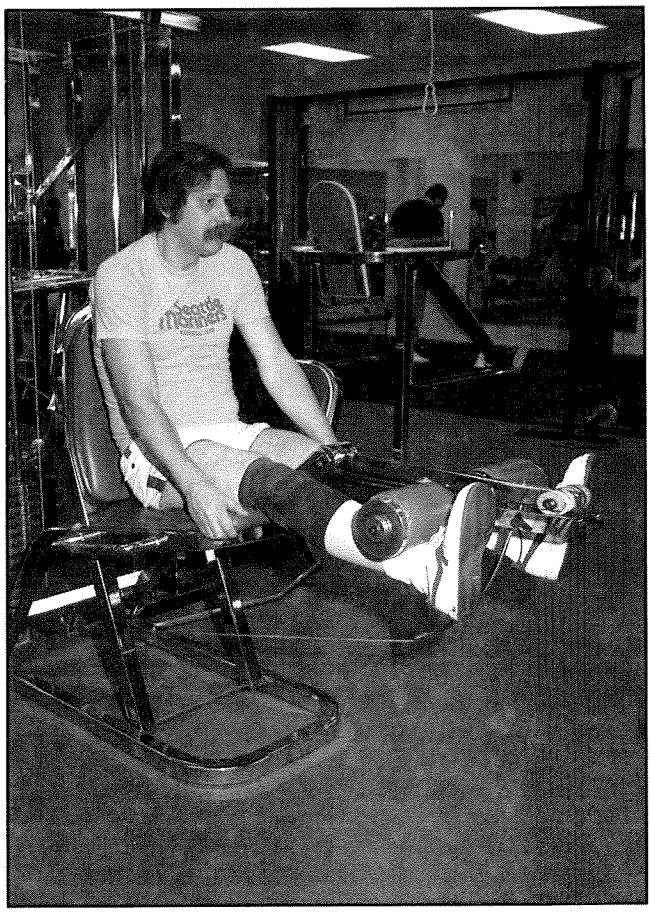
PURPOSE
Strengthens the quadriceps.

PROCEDURE
- Sit on the edge of the bench with the back of the knees touching the edge of the bench.
- Place the top of both feet and ankles against the foot pad. Sit with the back flat against the back support.
- Secure the seat belt, if available, and grasp the support handles or the sides of the chair.
- Extend the knees until both legs are nearly parallel to the floor. Hold the position briefly and then slowly lower the legs back to the starting position.

SKILL LEVEL
Intermediate.

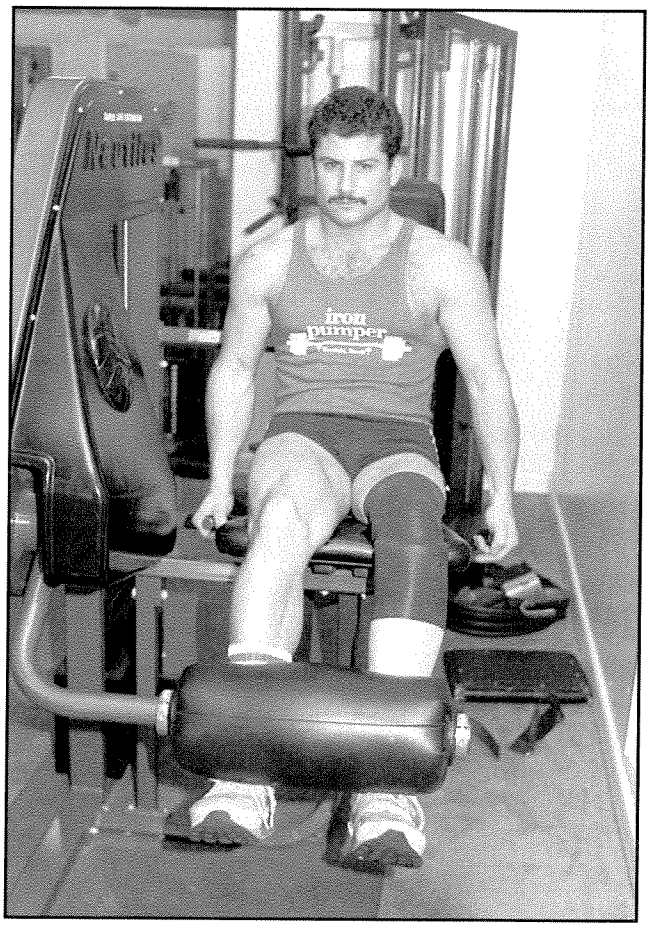
CAUTION

In this exercise, resistance is placed against the ankles and can be tolerated by those with long residual limbs. Some machines allow the foot pads to adjust upward, which will provide greater comfort for people with short residual limbs. However, people with short residual limbs may experience anterior distal pressure. In such a case, this exercise may be used for the sound leg only, or the One-legged Low Wall Pulley Knee Extension (Exercise 37) may be substituted, since it allows the resistance to be placed at a mid-socket point to relieve anterior distal pressure.



John Everett demonstrates the knee extension exercise from a seated position.

EXERCISE 38. SEATED KNEE EXTENSION (Continued)



Albert Rappoport demonstrates (on a slightly different type of equipment) the knee extension exercise from a seated position.

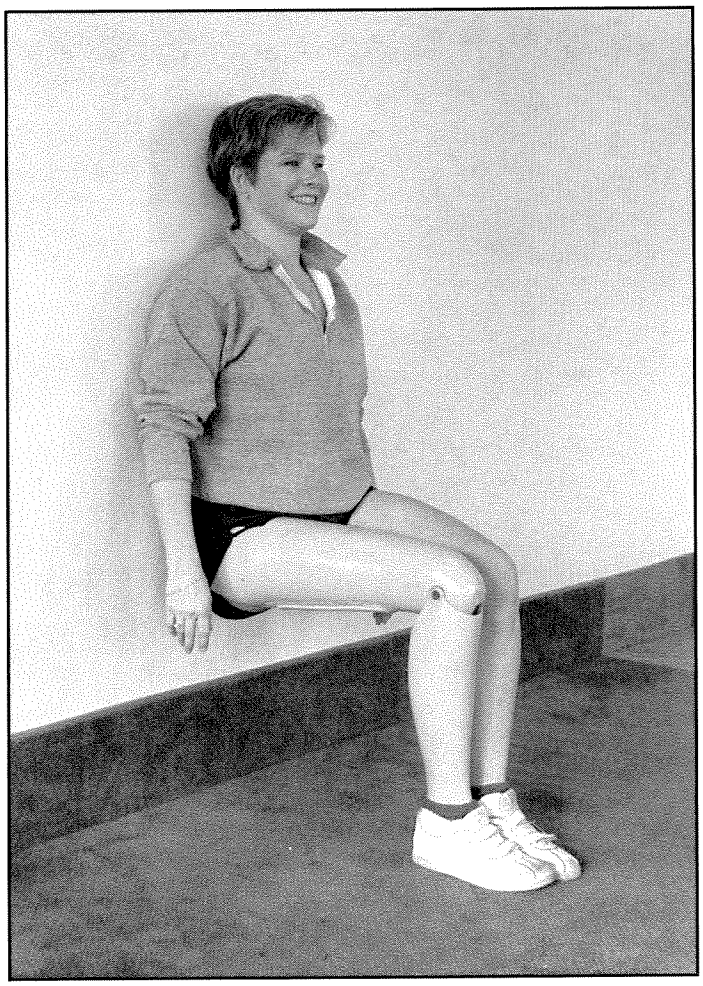
EXERCISE 39. SKIER'S POSITION

PURPOSE
Develops quadriceps muscles through static muscle contraction, including the muscles of the residual limb.

PROCEDURE
- Stand against a wall. With the back pressed to the wall, lower the body until the position shown in the photo is achieved.
- The hands may be used against the wall while lowering the body into position. Both feet should be flat on the floor and far enough away from the wall so that the upper portion of the legs are parallel to the floor and the lower portion of the legs are in a vertical position to the floor, as shown in the photo.
- Keep the hips positioned at the same height as the knees.
- Keep hands loose and shoulders back against the wall.
- Work up to holding this position for 30 seconds, and then relax for 30 seconds. Repeat three times every other day. Increase the time spent in the Skier's Position by 15 seconds each week.

VARIATION
Beginners should start with the buttocks higher than the knees, while keeping the back against the wall. More advanced individuals can gradually maintain a position where the hips are parallel to the floor. If this position is difficult to maintain, you may ease tension on the thigh muscles by placing your hands on your knees. Gradually increase the length of time spent in the Skier's Position and shorten the length of the rest periods to make the exercise more difficult.

SKILL LEVEL
Advanced.



Linda Pedersen demonstrates this static muscle contraction exercise.

EXERCISE 40. MOON BENCH LEG PRESS

PURPOSE

Strengthens the quadriceps and gluteus maximus muscles.

PROCEDURE

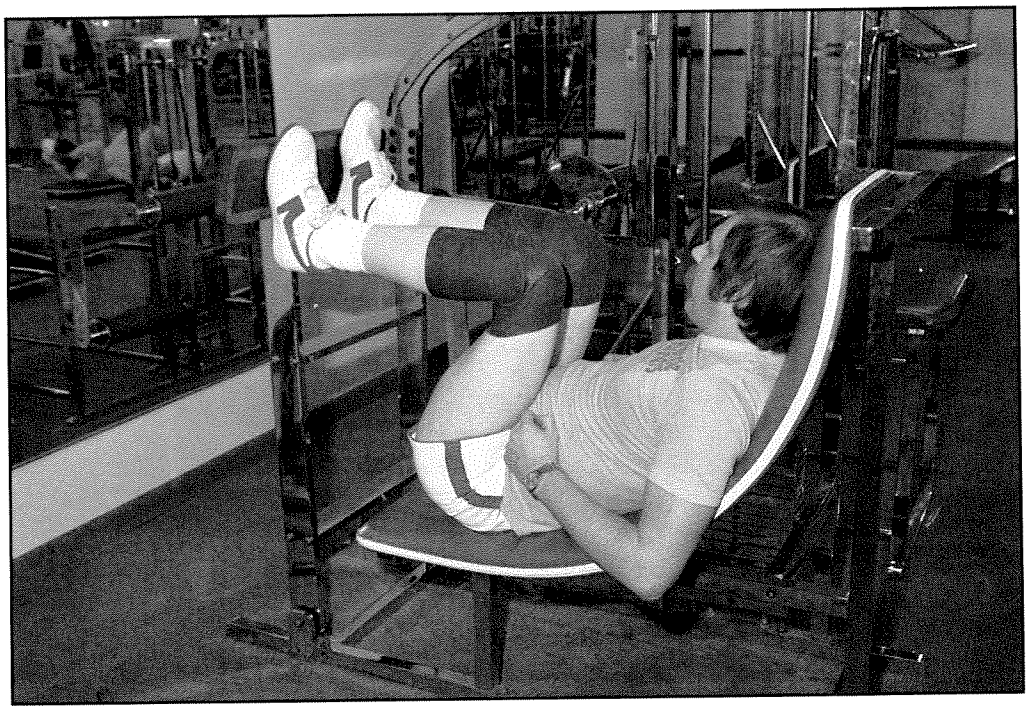
- Sit on the Moon bench so that the buttocks are at the front of the bench.
- Place both feet on the foot pad and space them several inches apart, as shown in the photo.
- Hold the bench under the buttocks for support, if needed. Push against the foot pad evenly with both legs until the legs are completely extended as shown.
- Slowly bring the legs back to the starting position.

MODIFICATIONS

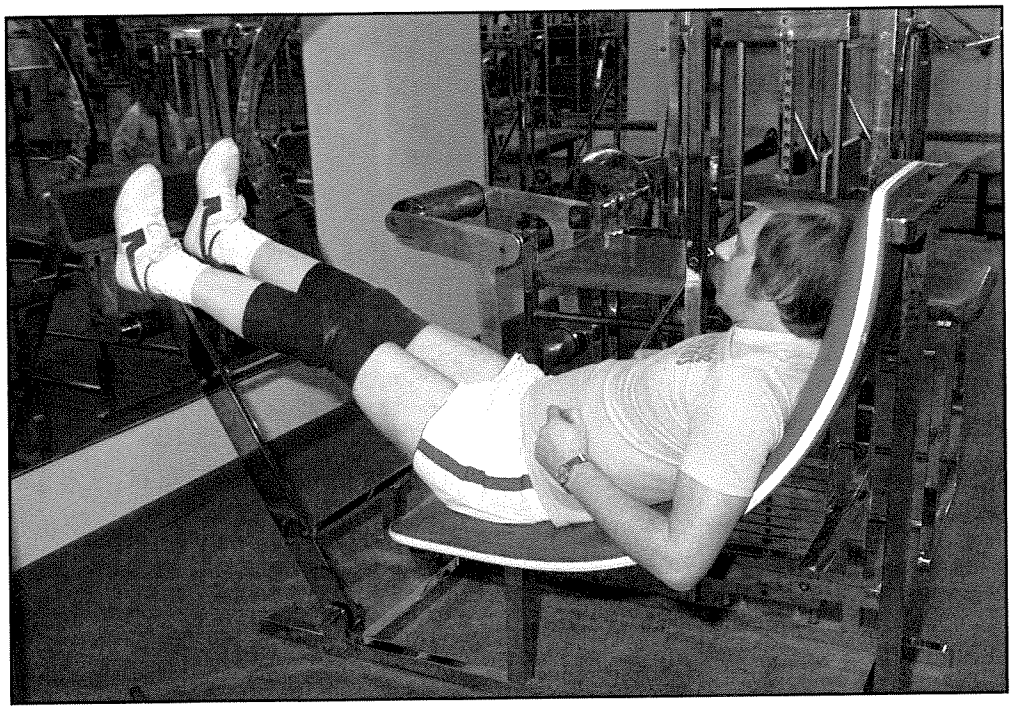
Certain prostheses may restrict flexion and extension of the knee for those with BK amputation. Adjustments may be necessary with suspension, posterior trim lines, or joints and lacer. Sleeve suspension is helpful in achieving full extension, although flexion may remain restricted in some cases. Lower posterior trim lines of the socket can help reduce pressure on the hamstrings.

SKILL LEVEL

Intermediate.



John Everett demonstrates the seated leg press using both prosthetic legs to achieve a full range of motion.



EXERCISE 41. NAUTILUS DOUBLE LEG PRESS

PURPOSE

Develops strength in the upper thighs and hips.

PROCEDURE

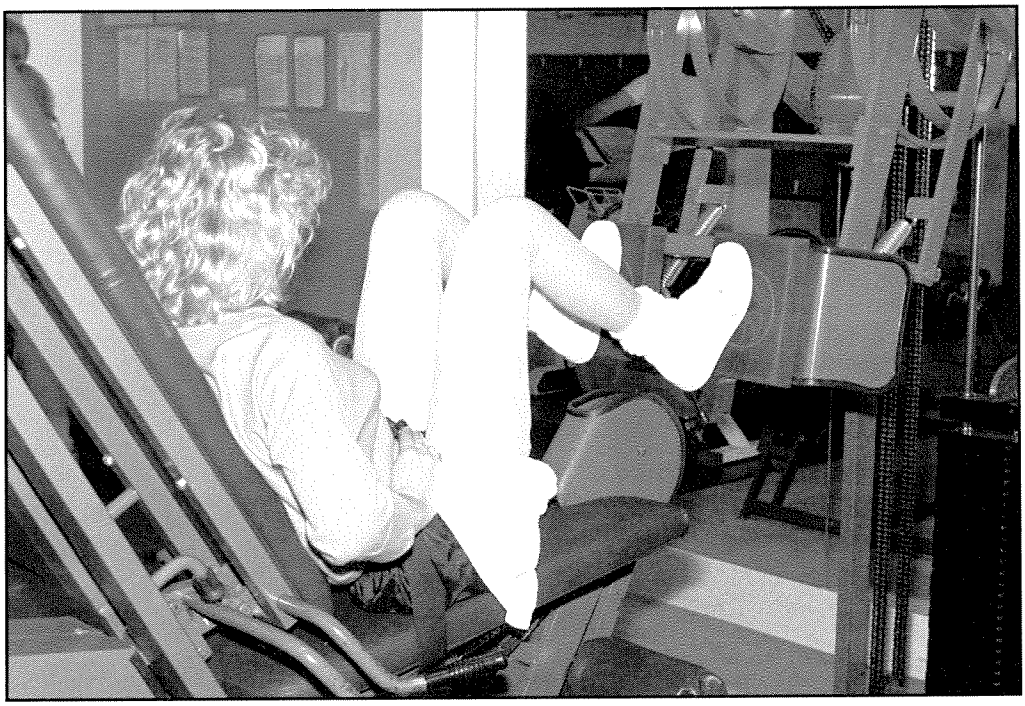
- Adjust the back of the seat so that your legs are at a 90-degree angle (or more) when your feet are placed flat on the footrests. Make sure you secure the seat belt as you keep your back flat against the backrest.
- Straighten the legs. After the legs have reached maximum extension, bring them back slowly until the knees are flexed to at least a 90-degree angle.
- Exhale while extending the legs and inhale as the knees are brought to the starting position.

MODIFICATIONS

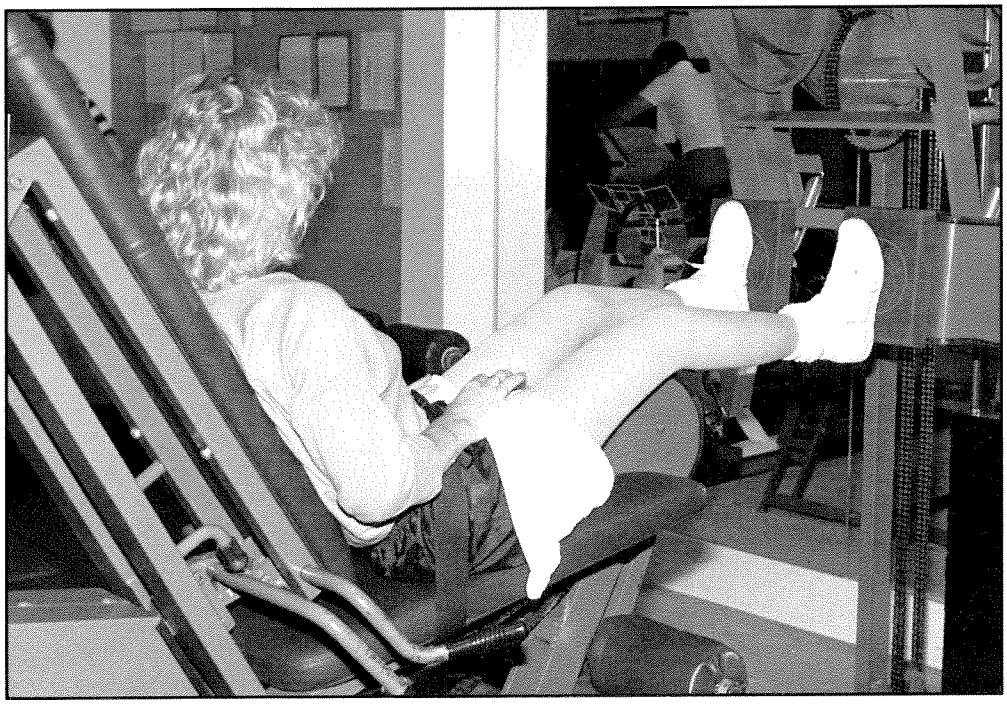
If you are breaking suction in your AK socket while flexing the hips, try moving the seat back so your legs do not go into as much flexion. You may also try lowering the anterior trimlines of your socket. Additional suspension using a Silesian bandage or Neoprene TES Belt may be helpful. Training the legs for the bilateral AK amputee should start with low weights. Those with BK amputation who find it difficult to bend the knee to a 90-degree angle should move the seat back to a lesser angle.

SKILL LEVEL

Intermediate.



Samantha Ellis is in the starting position with knees flexed.



Samantha Ellis pushes both of her residual limbs down in hip extension to extend her prosthetic legs. Knees are locked out as far as possible to complete the exercise.

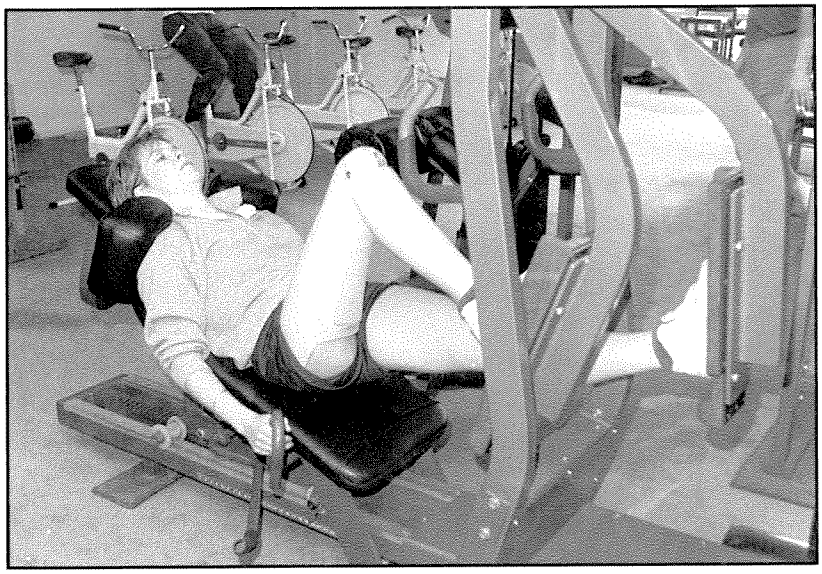
EXERCISE 42. ALTERNATING LEG PRESS (NAUTILUS DUO SQUAT MACHINE)

PURPOSE
Strengthens the quadriceps and hip extensors.

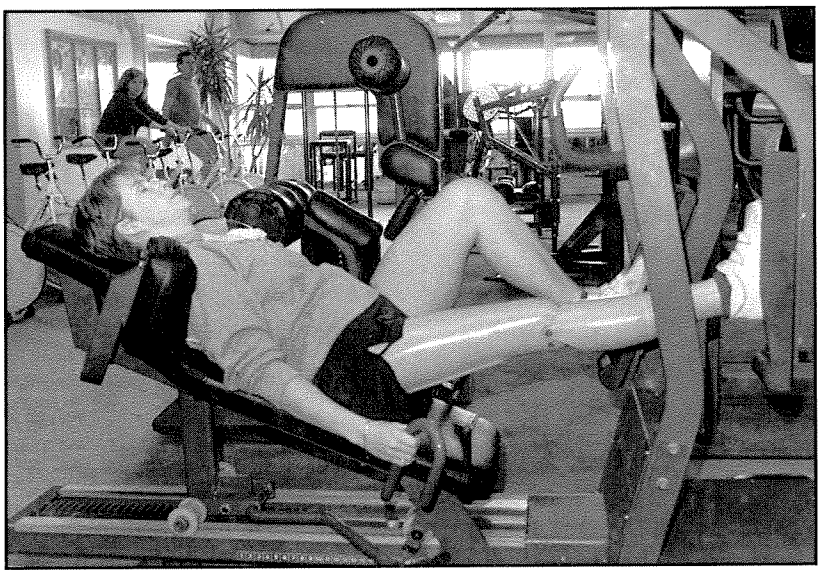
PROCEDURE
- Lie on the bench with shoulders pressed against the shoulder pads and hands gripping the support bars.
- Position both feet on the foot pads and extend both legs. Keep one leg extended and flex the opposite leg, as demonstrated in the photo.
- Press the flexed leg against the foot pad so that it is again extended.
- Continue to alternate legs, as shown in the photo.
- Always bring both legs to a fully extended position before beginning another flexion.

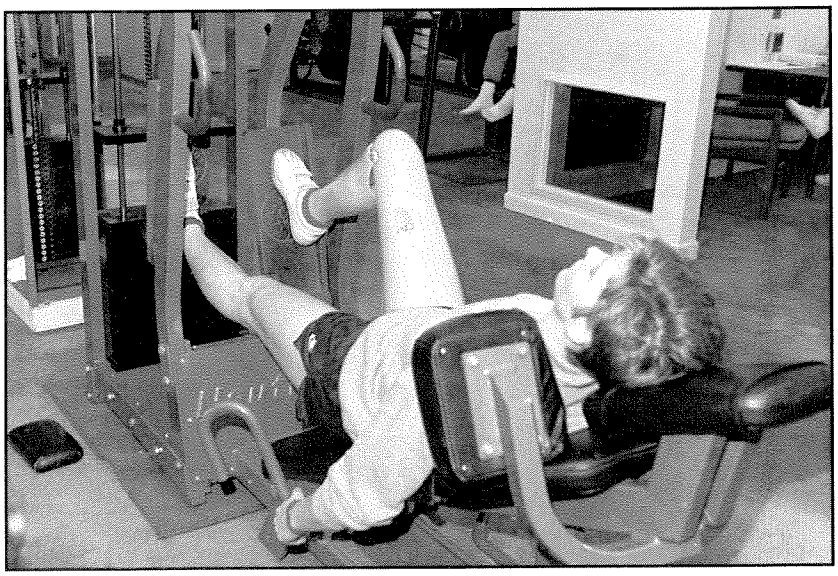
MODIFICATIONS
Because the weight needed to effectively exercise a sound leg is likely to be considerably greater than the weight needed for a prosthetic leg, it is best to exercise each leg independently. The legs are worked one at a time, and a lower weight (which can be gradually increased as strength develops) is placed on the side with the prosthesis. Some people with AK amputation may feel that they will not be able to do the exercise, but with practice, most will be able to. The AK-level individual can perform this exercise by extending the thigh, which extends the prosthetic knee. This works the muscle of the residual limb inside the socket.

SKILL LEVEL
Advanced.



Linda Pedersen demonstrates the alternating leg press exercise.





EXERCISE 43. HALF SQUATS

PURPOSE
Develops strength in the quadriceps muscles.

PROCEDURE
- Take a medium stance with the feet approximately 16 inches apart or a wide stance with the feet approximately 30 inches apart.
- Place your hands on the bar, positioning them wider than the shoulders.
- Rest the bar on the upper portion of the back.
- Keep your head up and your back straight at all times.
- From the standing position, squat until your thighs are parallel to the floor.
- Head is up, back straight, and knees are pointed out. Heels are elevated with the weight on the balls of the feet.
- Inhale while squatting; exhale as you return to the starting position, keeping legs extended and placing the heels on the ground.

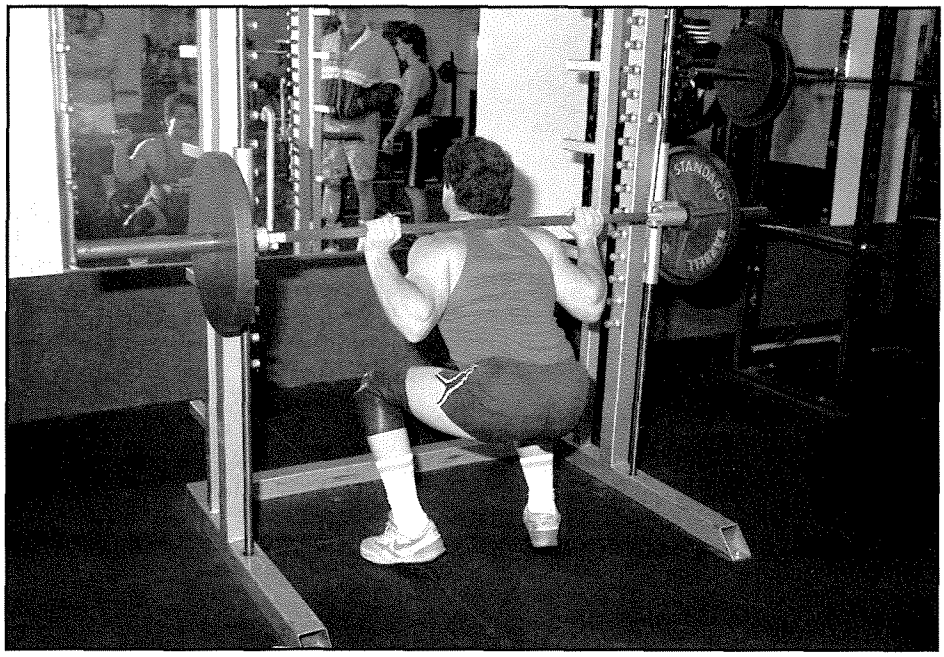
VARIATION
Use a weight belt to help protect the back from injury. The serious, competitive powerlifter may benefit from a special prosthesis that accommodates the wide stance and keeps the foot flat on the ground at all times for greater stability. For lifting light to medium weights, an everyday walking prosthesis is usually adequate.

MODIFICATIONS
Because Velcro™ on the cuff strap suspension may pull apart when fully flexed, suspension sleeves are particularly useful. The ActivSleeve is pictured on page 105. Trim lines may need modification on some prostheses to allow increased range-of-motion, particularly to medial and lateral walls and posterior trim lines.

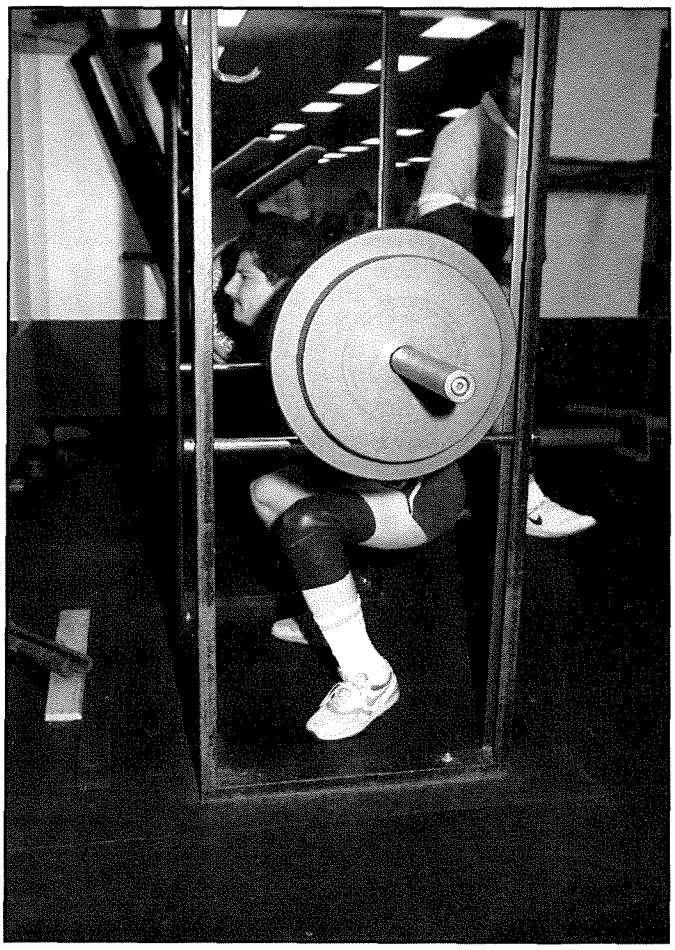
SKILL LEVEL
Advanced.

NOTE

A close stance (feet less than 16 inches apart) is usually not recommended for individuals with lower limb amputation because it makes it very difficult to maintain balance when squatting. Although squats generally are performed with a 2 x 4 board underneath the heels to elevate them through the entire exercise, this is not recommended for those with prostheses. The elevated position could create instability, throw the amputee lifter too far forward, and vary prosthetic alignment. It is possible to align a prosthesis just for squatting when standing on a 2 x 4 board. However, many prefer a special weight-lifting shoe with appropriate alignment.



Albert Rappoport demonstrates 90-degree half squats with 205 pounds. He performs squats using his everyday walking leg. Notice how weight is on the ball of the foot (prosthetic side) because the prosthetic ankle cannot bend as far forward as the sound side. This still provides adequate balance and support. Rappoport's heavy workouts include 3 sets of 5 repetitions with up to 275 pounds.



Even though a majority of the weight is taken on the sound side, squats are an excellent conditioning exercise for the residual limb.

EXERCISE 44. NAUTILUS HIP AND BACK MACHINE

PURPOSE

Strengthens hip extensor. Works the gluteus maximus and hamstrings. This exercise is good for those with AK amputations because it strengthens the musculature of the residual limb.

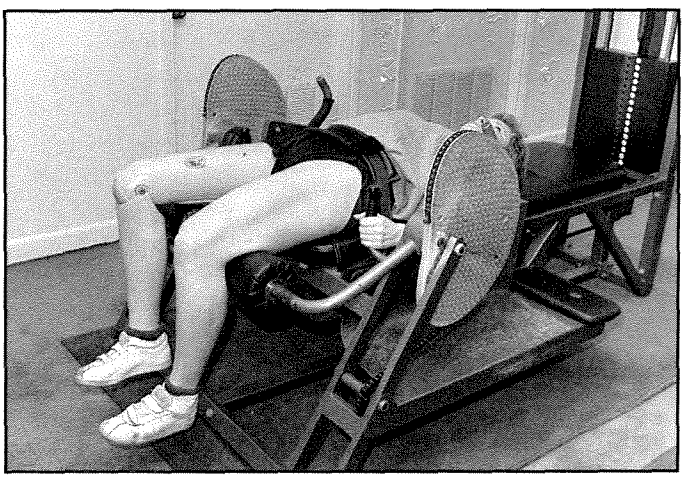
PROCEDURE

■ Step 1

— Lie flat on the bench, flex the hips so the thighs are vertical, and place the lower legs over the pads. Position yourself so that both hips are in line with the cam. (This will insure that the body's axis of rotation is lined up with the machine's.)

— Strap the seat belt across the waist and grip the handle bars on each side for support.

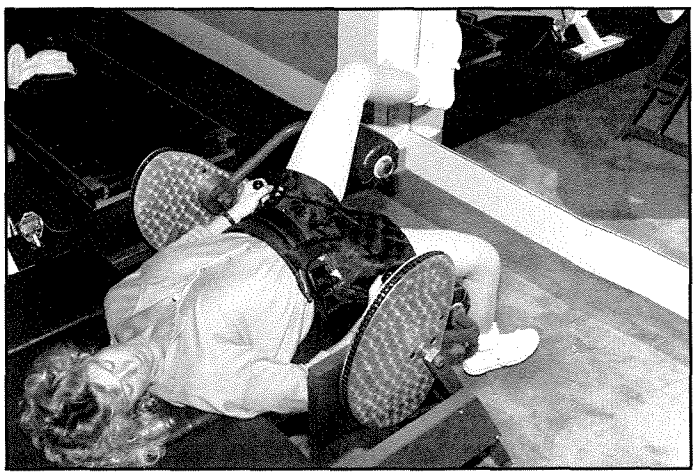
— Push down on both legs and touch both feet to the floor if possible, as seen in the Step 1 photos below. The extended legs hold down the weights by maintaining a static contraction on the lower back and hips.



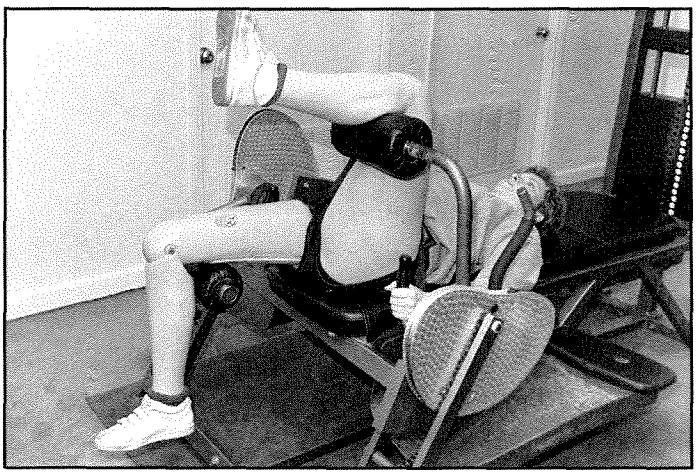
Samantha Ellis and Linda Pedersen demonstrate Step 1 of this exercise, which gets both legs in position to begin the repetitions. The Nautilus Hip and Back machine works the same muscles as does the pulley/cable used in Exercise 47, but it is not always available in small facilities. Some people with lower limb loss find it easier to use this machine than the pulley/cable.

■ Step 2

— Keep one foot in contact with the floor and bring the other leg up (with a count of four) until the thigh is flexed and perpendicular to the floor, as seen in the photos on the right.



— As shown, the leg in contact with the floor maintains static contraction holding the weight bar down while the other leg is brought up slowly until the thigh is in a vertical position.



■ Step 3

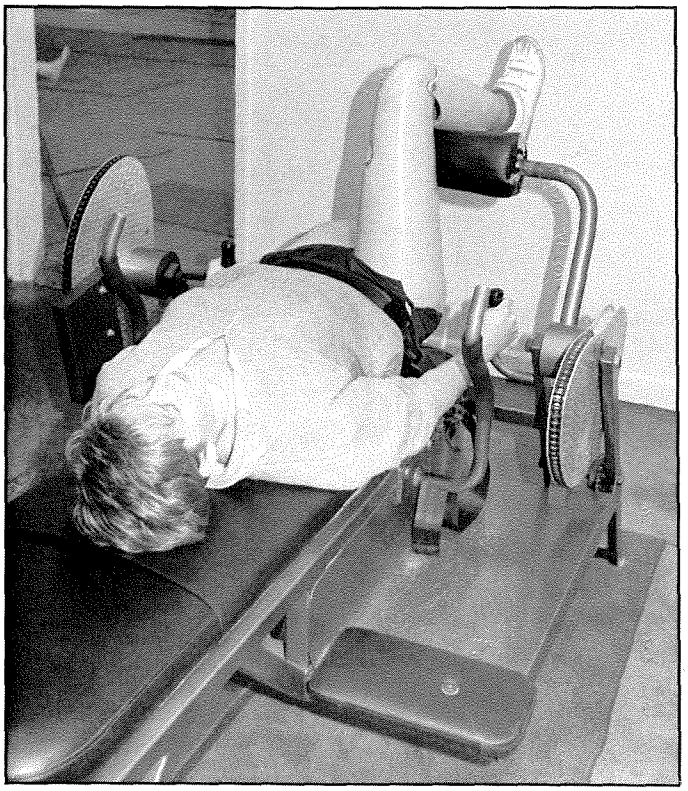
— Push the flexed leg down against the resistance of the weights by extending the hip until both feet are touching the floor with a count of two.

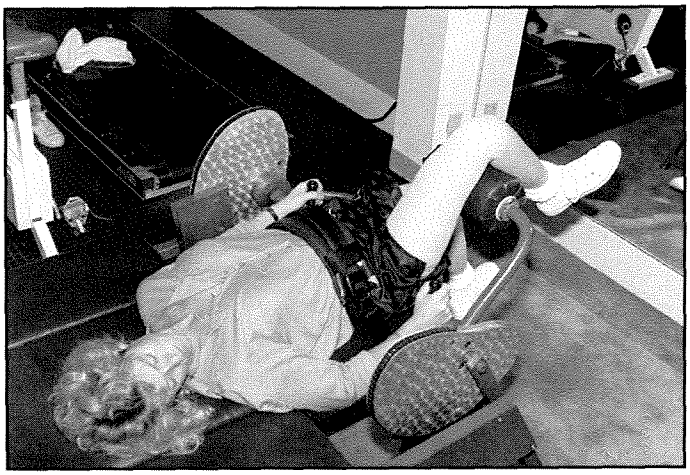
EXERCISE 44. NAUTILUS HIP AND BACK MACHINE (Continued)

■ Step 4

— Bring the other leg up slowly with a count of four, while the previously raised leg maintains static contraction against the weight resistance with the foot on the floor (same as Step 2, but with the other leg).

— Repeat Step 3 in preparation for another full repetition.





SKILL LEVEL

Intermediate to Advanced.

CAUTION

This exercise can be stressful to the lower back. Omit if low back problems are present.

EXERCISE 45. LEG CURL

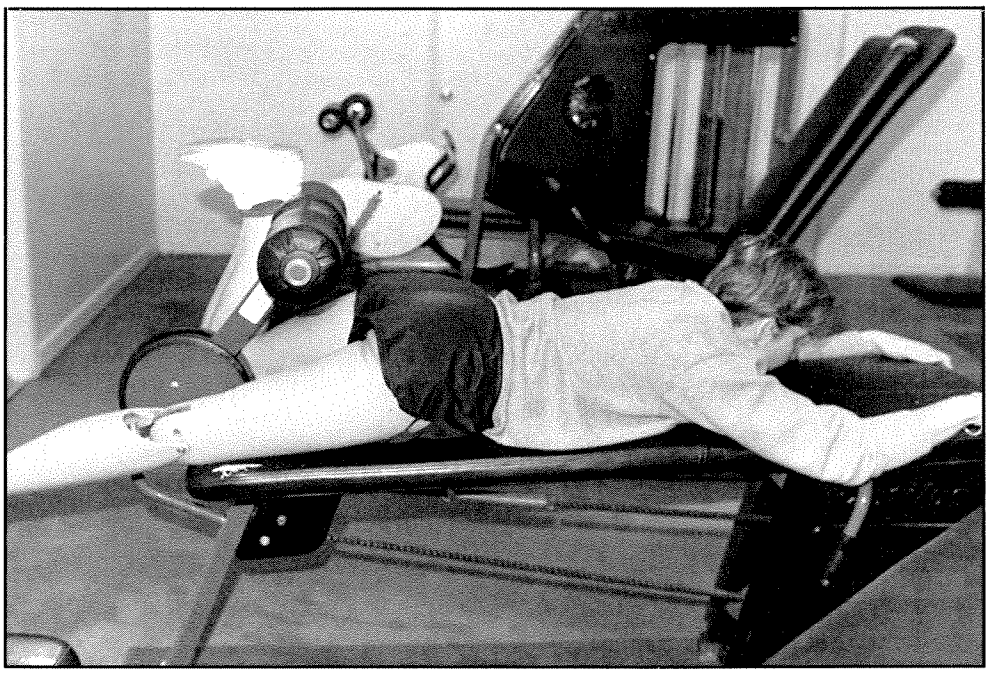
PURPOSE
Develops the hamstrings.

PROCEDURE
- Lie face-down on a leg curling bench.
- Make sure the knees are off the end of the bench and the legs are straight with the heels under the foot pads.
- Flex one leg as far as it will go, trying to touch the foot pad to the buttocks.
- Slowly lower the leg back to the extended position.

MODIFICATIONS
For those with AK amputation, working the residual limb from this position is not feasible because the knee is not controlled by muscles. Exercise 44, the Nautilus Hip and Back Machine, should be used. Those with BK amputations may not be able to complete full range of motion due to short residual limb size or flexion restrictions on prosthesis. Exercise 46 or 47 should be used as an alternative.

SKILL LEVEL
Intermediate.

CAUTION
Avoid arching the lower back.



On the Nautilus equipment, Linda Pedersen demonstrates the Leg Curl using her sound limb.

EXERCISE 46. STANDING ONE-LEGGED LOW PULLEY LEG CURL

PURPOSE
Develops the hamstring muscles.

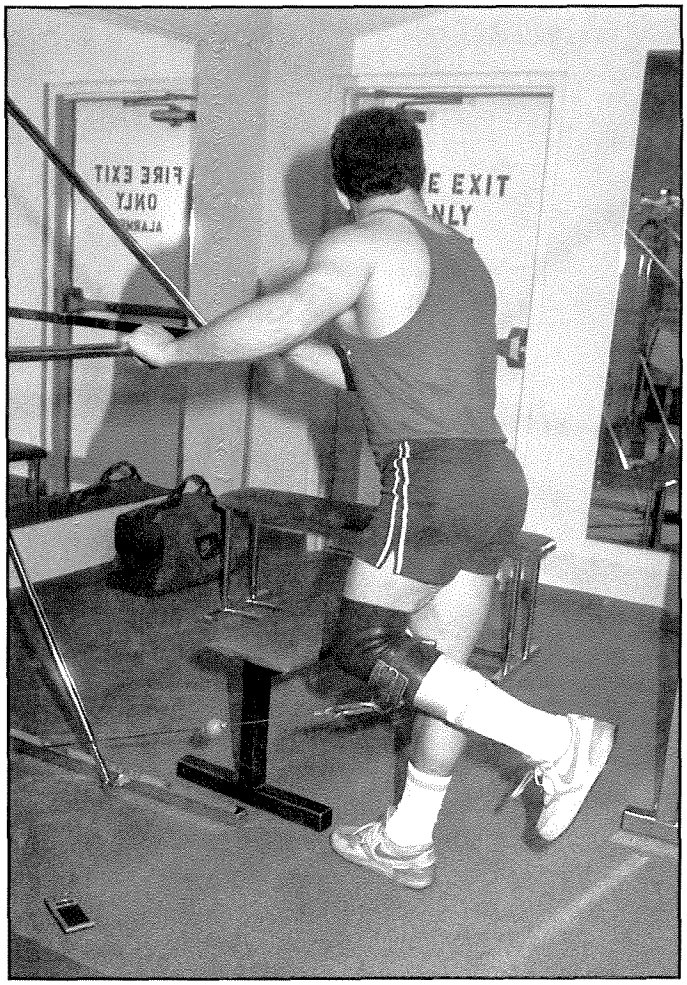
PROCEDURE
- Face the weight machine and place a cuff strap around the middle of the socket on the outside of the prosthesis. Adjust the position of the strap on the leg for maximum comfort.
- Hold on to the support bar and flex the knee on the prosthetic leg while balancing on the sound leg. Try to flex as much as possible before returning the foot to the floor.

MODIFICATIONS
Many people find it difficult to do leg curls from a prone position with their prosthesis (Exercise 45) and find the standing position better suited for them. However, the leather cuff and D-ring pulley should not be attached at the ankle level for those with a short residual limb because flexing would produce undesired forces and excessive stress on the residual limb, and would also make the exercise more difficult. In order to concentrate on the hamstring muscles, the best attachment point is at the middle of the socket. If the residual limb is long, the cuff strap may be worn on the lower part of the leg.

SKILL LEVEL
Intermediate.

NOTE

Most people with below-knee amputation will be able to flex to a maximum of 90 degrees. Trim lines of the socket, length of residual limb, and suspension will be limiting factors. In certain cases, your prosthetist can make accommodations. If balancing on the prosthetic leg presents a problem, exercise the sound leg on the leg curl bench as shown in Exercise 45.



Albert Rappoport demonstrates the correct form for Leg Curls for a person with a short residual limb wearing a BK prosthesis.

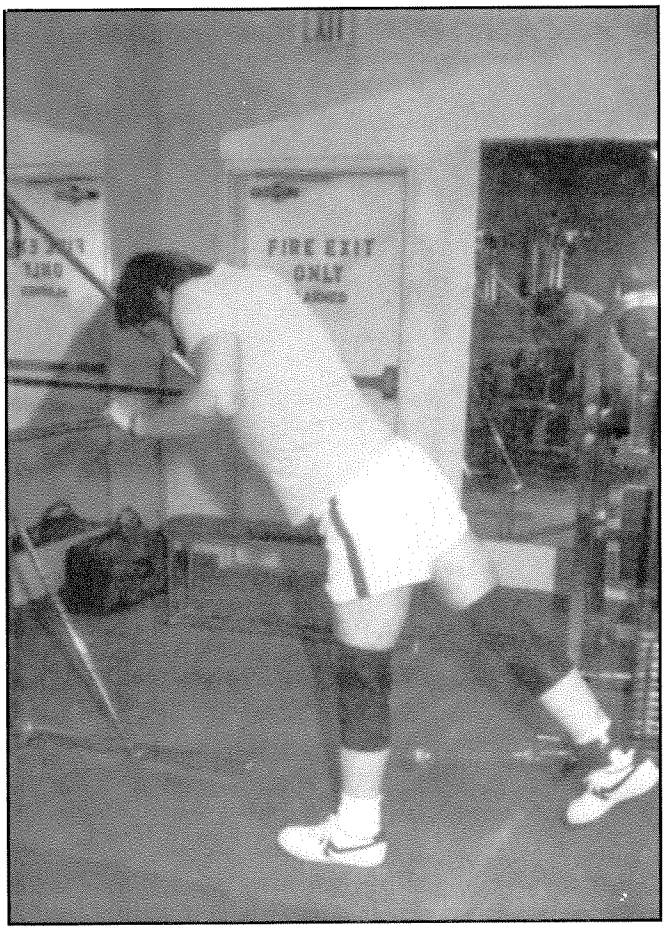
EXERCISE 47. STANDING PULLEY HIP EXTENSION

PURPOSE
Works the hamstrings and gluteus maximus.

PROCEDURE
- Attach the ankle cuff in a comfortable position to the exercising leg. Face the weights and hold the handrail for balance and support. Keep the trunk stationary and the back straight.
- Start with the legs together and then extend the weighted leg backward as far as possible. The other leg remains planted on the floor for support.
- When the back leg is fully extended, hold for a few seconds and then slowly bring the leg forward until it is even with the other leg and in a standing position.

MODIFICATION
For those with a short residual limb, exercise is often more comfortable when the cuff strap is placed higher on the leg.

SKILL LEVEL
Intermediate to Advanced.



John Everett demonstrates the use of the standing pulley weights to exercise the hamstrings and gluteus muscles of the thigh. Everett places the cuff strap at ankle height because his residual limb is long.

EXERCISE 48. NAUTILUS HIP ABDUCTION/ADDUCTION MACHINE

PURPOSE

Strengthens the abductor and adductor muscles of the hip. Improves endurance for walking and other ambulatory activities.

PROCEDURE 1: ABDUCTOR EXERCISE

- Before sitting down, adjust the thigh pads so they are on the outside of the leg rest as shown.
- Adjust the lever on the side of the machine to bring the leg rest portions together.
- When seated, secure the waist strap and place the legs inside of the thigh pads. Push against the thigh pads until your legs are as wide apart as they will go (see photo).
- Slowly bring the legs back together.

PROCEDURE 2: ADDUCTOR EXERCISE

- Adjust the thigh pads so they are on the inside of the leg rest.
- Adjust the lever on the machine to spread the leg pieces outward for a range of motion that is challenging but still comfortable, as shown in the photo.
- When seated, secure the waist strap and place the legs on the outside of the thigh pads.
- Press against the pads until they touch each other and the legs are at mid-line. Slowly let the legs retract out until they are at full spread position.

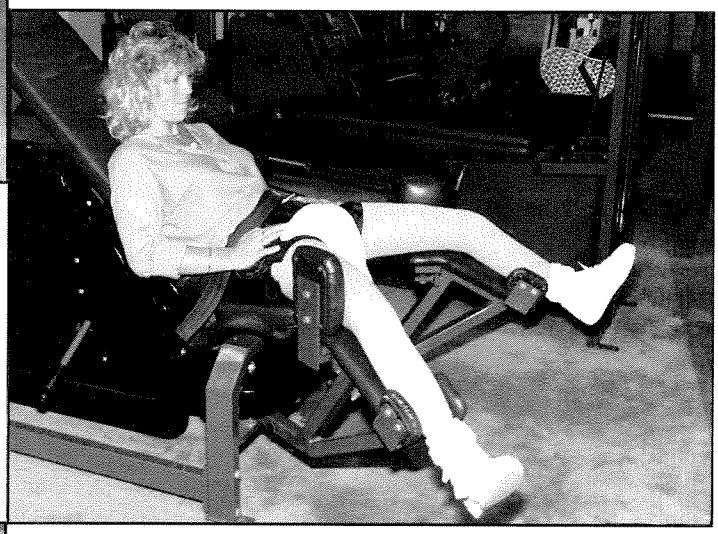
MODIFICATIONS

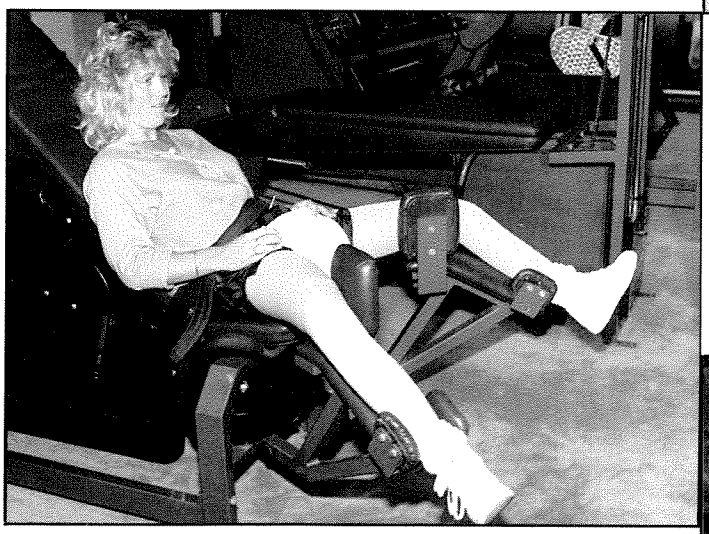
Weight resistance should be minimal for beginners. If you have never used this machine before, ask an instructor to show you how to change positions for abduction and adduction.

SKILL LEVEL

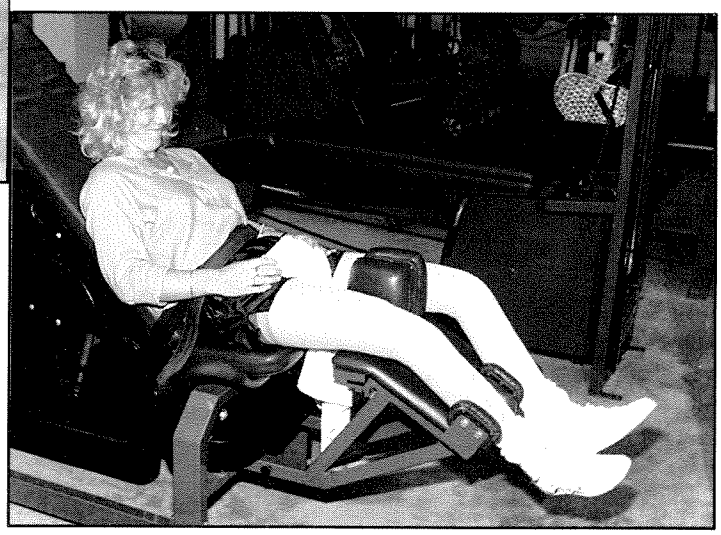
Intermediate.

PROCEDURE 1. ABDUCTOR EXERCISE





PROCEDURE 2. ADDUCTOR EXERCISE



EXERCISE 49. LOW PULLEY SINGLE HIP ABDUCTION

PURPOSE
Exercises the abductors of the hips.

PROCEDURE
- Secure the cuff strap to the prosthesis of the leg furthest from the weights.
- Stand with the feet close together and pull the cable away from the stack of weights by extending the working leg out from the mid-line of the body, as shown. Hold for a count of two.
- Bring the leg back slowly (with a count of four) to the standing position before repeating the exercise.

MODIFICATIONS
For maximum workout benefits, place the cuff strap higher on the prosthesis for short residual limbs and lower for long residual limbs. Many people find it most comfortable to place the cuff strap around the prosthesis where the middle section of the residual limb is located. If standing is too difficult, try working the abductors from a seated position (shown in Exercise 49).

SKILL LEVEL
Intermediate to Advanced.

John Everett demonstrates the exercise, maintaining his balance by holding on to the handrail.

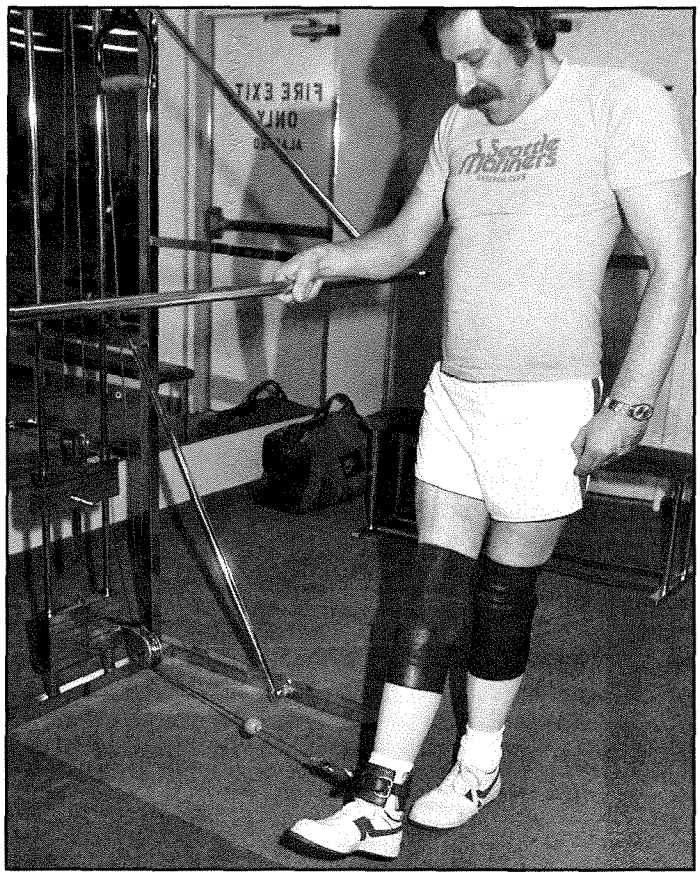
EXERCISE 50. LOW PULLEY SINGLE HIP ADDUCTION

PURPOSE
Exercises the adductors of the hip.

PROCEDURE
- Secure the cuff strap to the prosthesis of the leg closest to the weights.
- Stand with feet slightly apart.
- Move the strapped inside leg forward, away from the leg used for balance, so adequate clearance is available.
- Pull the cable away from the stack of weights toward the stationary outside leg until they meet, or until the working leg slightly passes the standing leg.
- Return the working leg to the starting position before repeating the exercise.

MODIFICATIONS
For maximum workout benefits, place the cuff strap higher on the prosthesis for short residual limbs and lower for long residual limbs. Many people find it most comfortable to place the cuff strap around the prosthesis where the middle section of the residual limb is located. If standing is too difficult, try working the adductors from a seated position (shown in Exercise 49).

SKILL LEVEL
Intermediate to Advanced.



John Everett demonstrates the exercise, again maintaining balance by holding on to the handrail.

EXERCISE 51. WEIGHTED STANDING CALF RAISE (NAUTILUS MULTIPURPOSE MACHINE)

PURPOSE

Develops the calf muscles, especially the two heads of the gastrocnemius. Strengthening the calf will help prevent premature muscular fatigue when performing daily activities.

PROCEDURE

- Adjust the weight to the desired resistance and place the attached belt around your waist.
- Position the sound leg with the ball of the foot on the first step, allowing the heel to hang over the edge of the step. Keep the prosthetic leg on the floor.
- Keep your head up and your back and knee straight during the exercise.
- Hold the support bars and raise up on your toes. Raise as high as you can and hold the position momentarily.
- Lower your foot as slowly as possible so that your heel drops well below the step.
- Raise back up to contract the calf muscle.

VARIATIONS

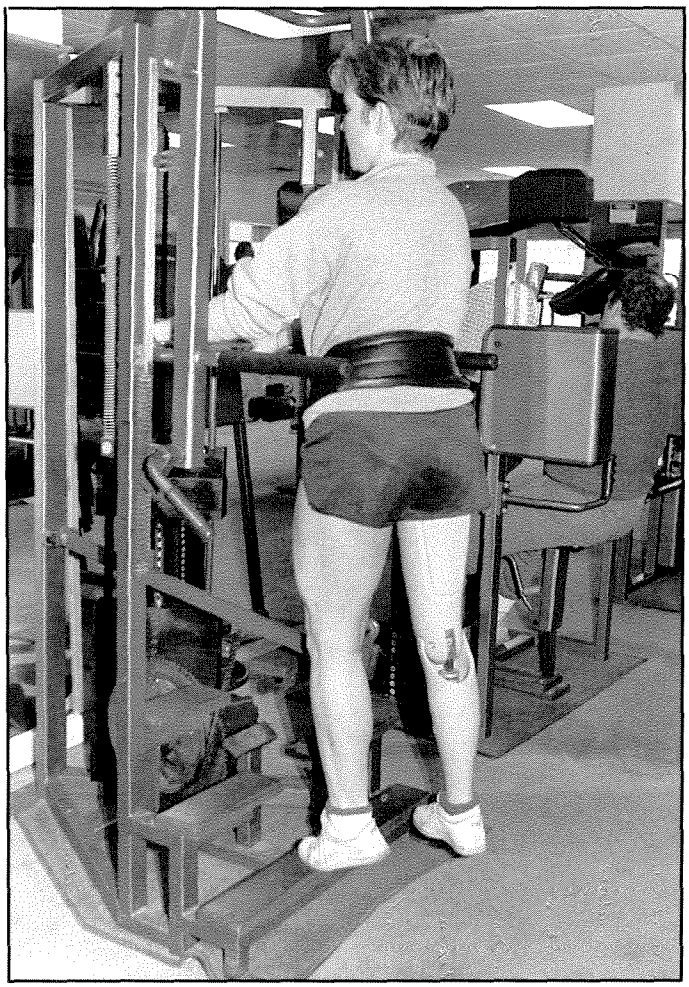
— Toes facing straight ahead works the main calf muscles.
— Toes facing in and heels out works the outer calf muscles.
— Toes facing out and heels in works the inner calf muscles.
— All three positions are necessary to achieve fully developed calf muscles.

MODIFICATION

The prosthetic leg is not placed on the step.

SKILL LEVEL

Advanced (primarily because only one leg is being used at a time).



Linda Pedersen works on the multipurpose machine to develop strength in her sound leg.

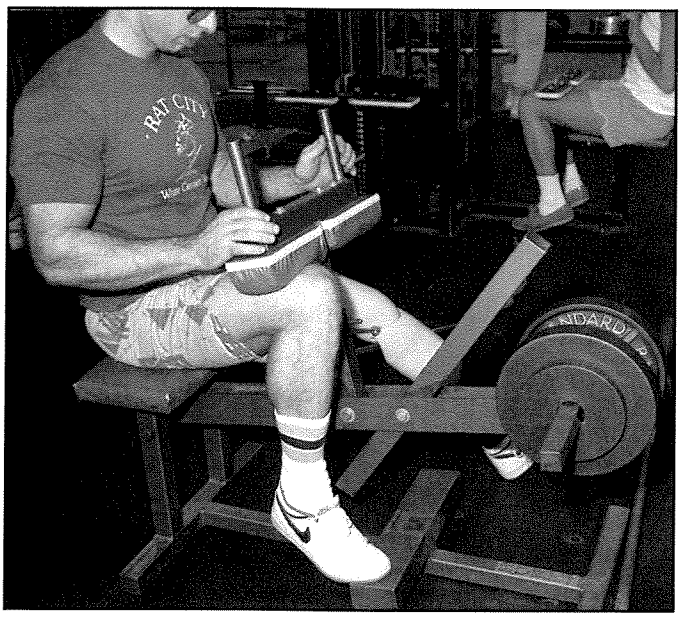
EXERCISE 52. SEATED ONE-LEGGED TOE RAISE

PURPOSE
Develops gastrocnemius/soleus muscles. The seated toe raise is one of the best ways to develop the underlying soleus muscle.

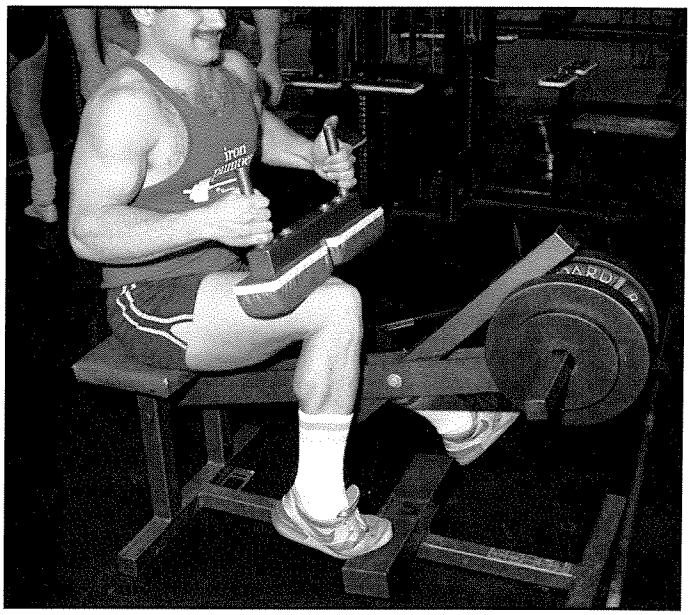
PROCEDURE
- Sit on the calf machine and adjust the upper leg pad so that it touches the thigh and is positioned just above the knee.
- Position the balls of the feet so they are directly below the leg pad.
- Push up thigh pad with calf muscle contraction and release the safety stop.
- Let go of the safety stop and lower your heel as far as is comfortable, trying to get a good stretch. Lower your heel to well below the foot rest.
- Raise up on your toes, bringing your heel up as high as you can.
- When you reach the highest position, hold that contraction momentarily before lowering the heel back down to the starting position.
- Try to get a complete range of motion on each repetition.
- Use only the calf. Do not pull with the hands or flex the thigh except on the last repetitions which you could not normally complete otherwise.

MODIFICATION
Keep prosthetic leg out to the side because it is not exercised.

SKILL LEVEL
Advanced.



Mike Nitz demonstrates the exercise with the toes pointed outward, thereby working the inner calf.



Albert Rappoport demonstrates the exercise with the toes pointed inward, thereby working the outer calf.

10

ABDOMINALS

The abdominal muscles—rectus abdominus and the internal and external obliques—are part of the group that form the trunk musculature. Weak abdominal muscles are a cause of bad posture and may be a predisposing factor in chronic lower back pain. Strengthening these muscles will firm the waistline, improve posture, and result in a trimmer appearance. However, abdominal exercises do not spot-reduce fat from around the abdomen and waist. Fat is lost only by expending more calories than are consumed.

The sit-up is one of the most common exercises for abdominal strengthening and toning. The Bent-Leg Sit-up is popular because it does not cause excessive stress on the lower back. Straight-Leg Sit-ups are not recommended and should be avoided because they may cause undue strain on the lower back. (Straight-Leg Sit-ups work the hip flexor muscle as opposed to the abdominals.)

Many authorities agree that (depending on the type of exercise) abdominal muscles, unlike most other muscle groups, can be worked on a daily basis. Weight-resistive abdominal exercises should usually be alternated with a day of rest. Rate of progress is an individual judgment, but in the beginning it is best to proceed slowly.

Abdominal exercises may be used for fully defined muscular development or as a warm-up routine for other exercises and sports. In a muscular development routine, abdominal muscles are strengthened by:

1. increasing the number of repetitions per set
2. increasing the number of sets
3. progressively shortening the rest periods between sets
4. increasing the angle of the exercise
5. strapping on leg weights for some exercises or holding a weight plate while performing other exercises.

Abdominal exercises are usually performed with higher repetitions per set than are most weight-training exercises.

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

ABDOMINAL EXERCISE ROUTINE

Muscle	Exercise	Title
Warm-up/Abdominals/Hip Flexors	53	Supine Leg Raise
Abdominals/Hip Flexors	54	Jackknife Sit-up
Abdominals/Hip Flexors	55	Bent-Leg Sit-up
Upper Abdominals/Hip Flexors	56	Bent-Knee Crunch
Abdominals/Hip Flexors	57	Incline Bench Sit-up with Variations
Abdominals/Hip Flexors	58	Nautilus Abdominal Chair
Lower Abdominals	59	Vertical Bench Bent-Knee Raise
Lower Abdominals/Hip Flexors	60	Vertical Bench Straight-Leg Raise
Lower Abdominals/Hip Flexors	61	Incline Leg Raise
Internal/External Obliques	62	Side Bends with Dumbbell
Internal/External Obliques	63	Side Bends/Hyperextension Bench
Upper Abdominals/Hip Flexors	64	Straight-Leg Sit-up/Hyperextension Bench
Abdominals/Shoulder Extensors	65	Exercise Wheel

EXERCISE 53. SUPINE LEG RAISE

PURPOSE
Warm-up and strength conditioning of the lower abdominal muscles and hip flexors.

PROCEDURE
- Lie flat on your back with arms at sides and legs close together and straight out.
- Keep the heels close together while raising the legs 3 to 6 inches off the floor.
- Tighten abdominal muscles and tilt pelvis to flatten the lower back against the floor. This will stabilize the pelvis and protect the back. Hold the legs in this position for a few seconds. Increase the time gradually, week by week.
- For beginners, three sets are suggested with a 30-second to 1-minute rest period between each set.

MODIFICATIONS
The prosthetic knee is locked in the straight position to prevent it from flexing. A person with AK amputation who does not have a locking knee unit can support the prosthesis and prevent it from flexing by placing the sound limb underneath the prosthesis or by pressing the heels together.

SKILL LEVEL
Beginner.

Linda Pedersen exercises with her above-knee quad socket, Mauch SNS Knee Unit, and Otto Bock SACH Foot.

CAUTION

This exercise can be stressful to the lower back. Omit if low back problems are present.

EXERCISE 54. JACKKNIFE SIT-UP (ALSO KNOWN AS V-UP SIT-UP)

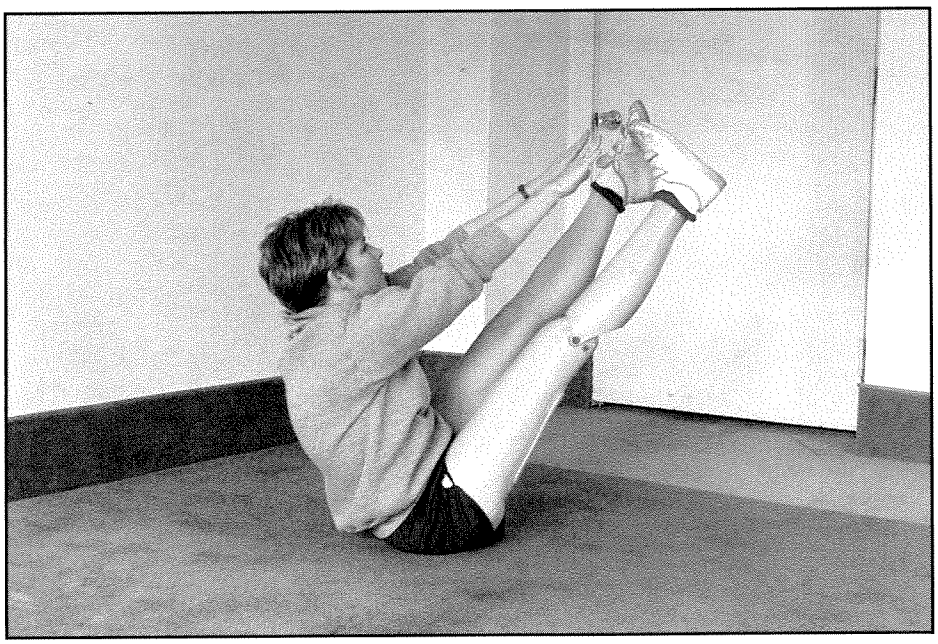
PURPOSE
Strengthens the upper and lower abdominal muscles and hip flexors.

PROCEDURE
- Lie on the floor in a supine position with legs straight out in front and arms extended behind the head.
- Keep the elbows and knees straight throughout the exercise.
- Simultaneously bring legs and arms together in a position as close to a vertical position as possible while bending from the waist.
- Lower the limbs to the supine position to complete each repetition.
- Do not rest while in the supine position.
- Inhale as you lower the legs and arms to a supine position and exhale as you come up to a vertical position.

MODIFICATIONS
The prosthetic knee should be locked in extension to prevent it from flexing. A flexible brim above-knee socket may help in flexing the hip further while reaching the vertical position.

SKILL LEVEL
Advanced.

CAUTION
Ms. Pedersen keeps her back very straight as she reaches the top position because she has been conditioning for many years. Beginners and those with chronic back pain should not attempt to reach as high, but only try to reach the mid-calf, shins, or ankles. Start with the Bent-Knee Crunch (Exercise 56) or the Nautilus Abdominal Chair (Exercise 58) until you are ready to do the Jackknife Sit-ups. As strength of the abdominal muscles is developed, there will be less risk of possible back injury in daily activities and other exercise routines.



EXERCISE 55. BENT-LEG SIT-UP

PURPOSE

Strengthens the abdominal muscles and hip flexors.

PROCEDURE

- Lie flat on your back with hands clasped behind your head.
- Bend the knees to about a 45-degree angle and have someone hold your feet to the floor.
- Bend at the waist and bring your elbows up to your knees.
- Lower your body slowly and let your shoulders touch the mat.
- Exhale as you bring your body up and inhale as you lower it down.
- Repeat the exercise without pausing in order to keep tension on the abdominal muscles.

MODIFICATIONS

For the person with AK amputation, the suspension of the sockets must be good and trimlines low enough to allow adequate hip flexion. To work the oblique muscles, twist your trunk as you raise it. Do not come up all the way if you are not able to complete at least 15 repetitions. If you are a beginner, start by only raising your head to complete a sit-up. If you can do that, raise your shoulders off the mat on the next set. Later, proceed to a half sit-up and then to a full sit-up as your strength increases.

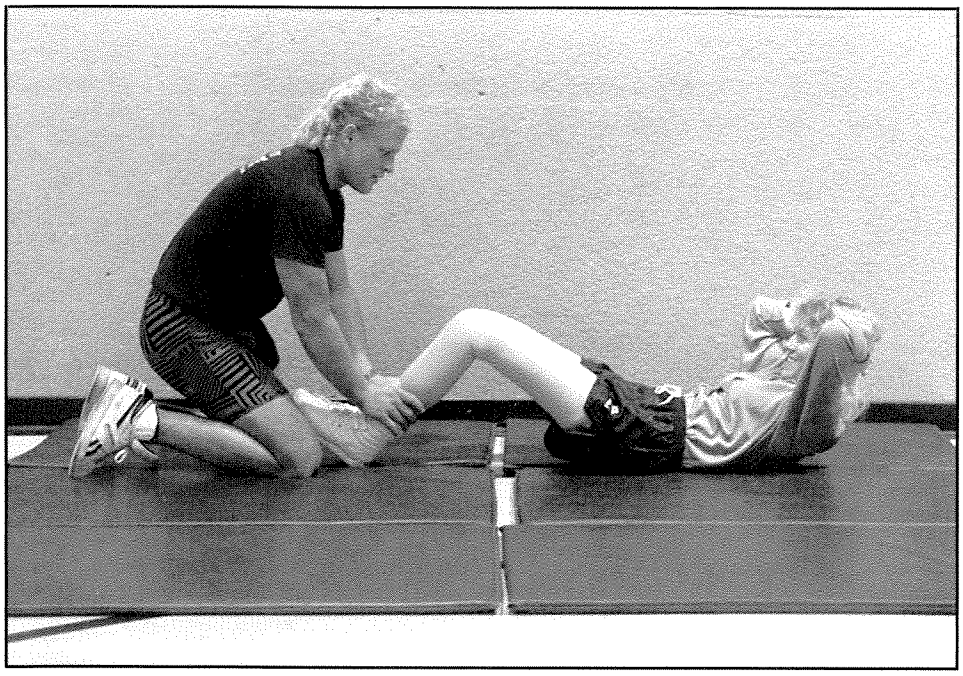
SKILL LEVEL

Intermediate.

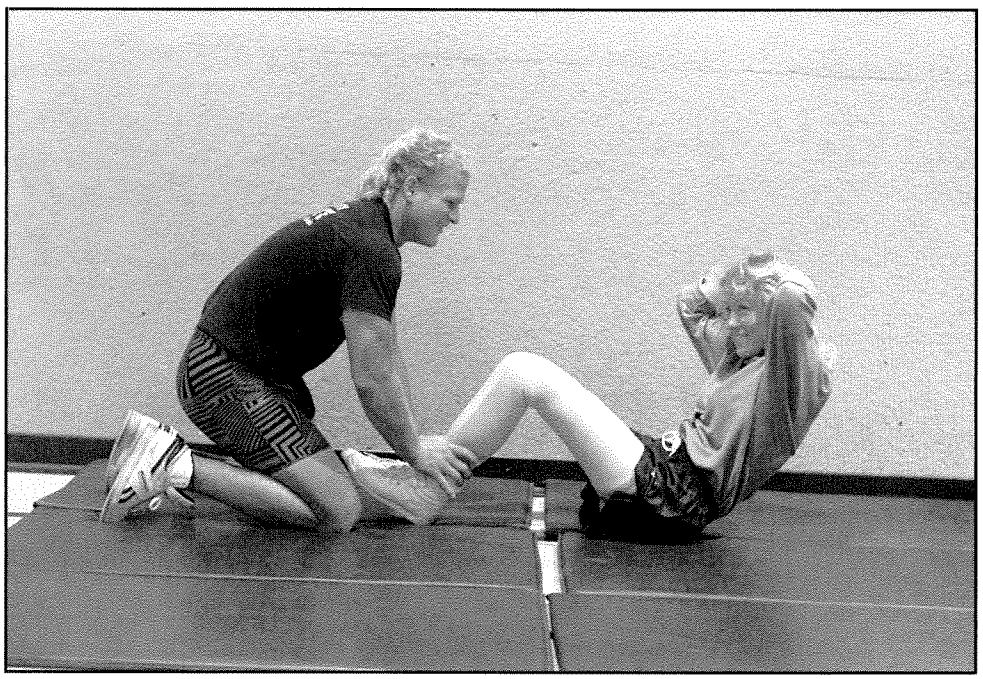
NOTE

The person with a unilateral amputation will experience greater tension on the sound limb as both legs are held down.

Bent-Leg Sit-ups are easier on the back than are Straight-Leg Sit-ups. They also allow for better isolation of the abdominal muscles because they do not require as much use of the hip flexor muscles. Many beginning exercisers use this type of sit-up at first, since climbing onto and balancing on an incline bench is difficult for some people. However, the advantage of the Incline Bench Sit-up (Exercise 57) is that no partner is needed.



Samantha Ellis is assisted by Greg Mannino.



EXERCISE 56. BENT-KNEE CRUNCH

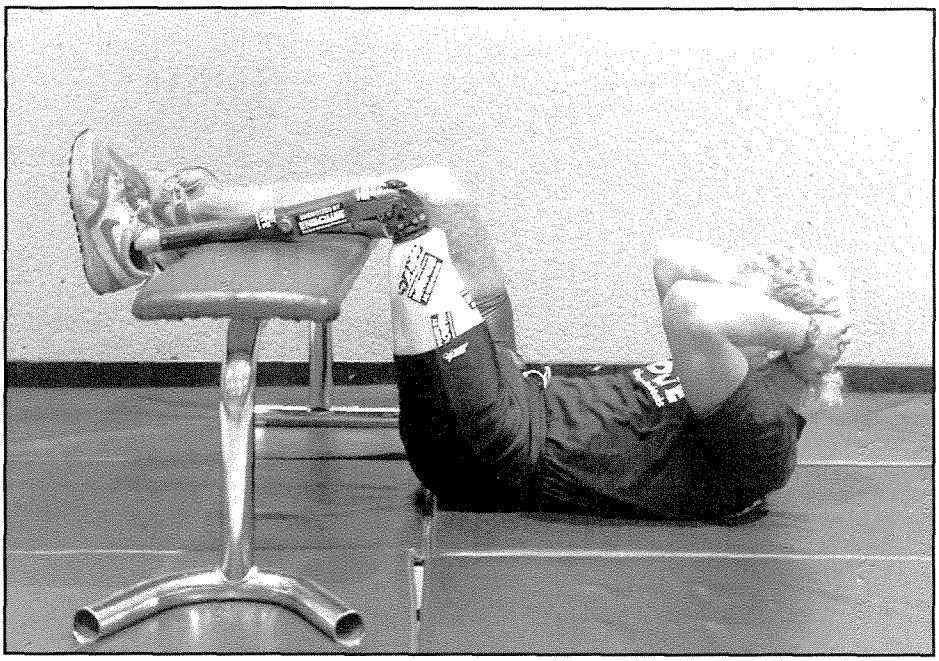
PURPOSE
Strengthens the upper abdominals and hip flexors.

PROCEDURE
- Lie on a padded surface and place your legs on a bench so that your thighs are at a 45-degree angle.
- Clasp your hands behind your head and pull your head and upper body from the floor using only the abdominal muscles.
- Lead with the elbows as shown in the photos. Beginners should start with a partial sit-up, lifting just the head and shoulders off the mat (see photo).
- As strength and endurance are developed, increase to a 45-degree sit-up. This exercise is very effective when 15-25 sit-ups can be completed in succession with no pauses in between repetitions.

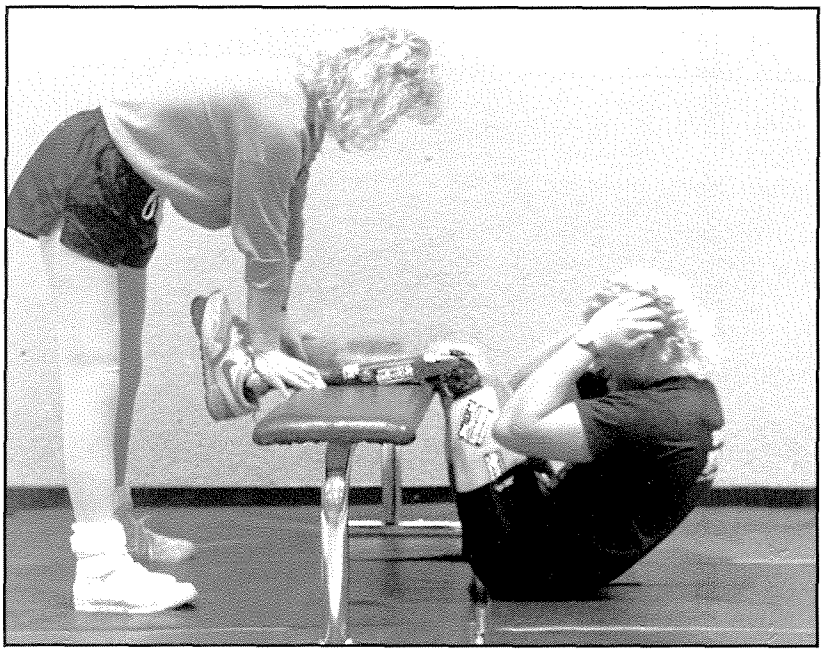
VARIATION
To work the intercostal muscles as well, twist to left and right sides alternately as you raise your torso to your legs. The routine for working the intercostals will be: center, right; center, left; center, right, etc.

SKILL LEVEL
Advanced.

CAUTION
If you begin to feel back strain, raise only the shoulders and head, and only as high as is comfortable.



Greg Mannino does a half sit-up, demonstrating the appropriate position for a person who has a back problem or is a beginner. (Notice that the low back remains in contact with the floor.)



Samantha Ellis assists Mannino by holding his legs in place while he does a full sit-up.

EXERCISE 57. INCLINE BENCH SIT-UP WITH VARIATIONS

PURPOSE
Develops and strengthens the upper abdominal muscles and hip flexors.

PROCEDURE
- Adjust the sit-up board to the desired height.
- Sit on the incline board and place your feet underneath the foot bar. Flex your knees to about a 45-degree angle.
- Place your hands behind your head or across your chest (whichever is most comfortable) and tuck in your chin. (Hands behind the head is the most difficult position.)
- Arms may be held in a variety of positions but must remain fixed during the exercise to keep from swaying and to minimize excessive body movement. Concentrate on pulling up your body using only the abdominal muscles.
- Lie back flat on the bench to begin the sit-up.
- Bend at the waist and bring yourself to an upright position (45 degrees) until your elbows are at about the same height as your knees. Slowly return to the starting position.
- Repeat the exercise without pauses in order to maintain tension on the abdominal muscles. To keep tension on the abdominal muscles, do not come up too high or rest your back on the bench on the way down.

VARIATIONS
For increased resistance, hold the weights behind your head or on your chest while doing sit-ups. To also work the oblique muscles, twist the upper body to each side, alternating each turn (i.e., center, left; center, right; center, left; etc.).

MODIFICATIONS
The prosthesis should have good socket suspension; the AK prosthesis should have a flexible brim socket when possible. Before the legs are placed underneath the bar, position the prosthesis with your hands or get assistance getting on and off the incline bench.

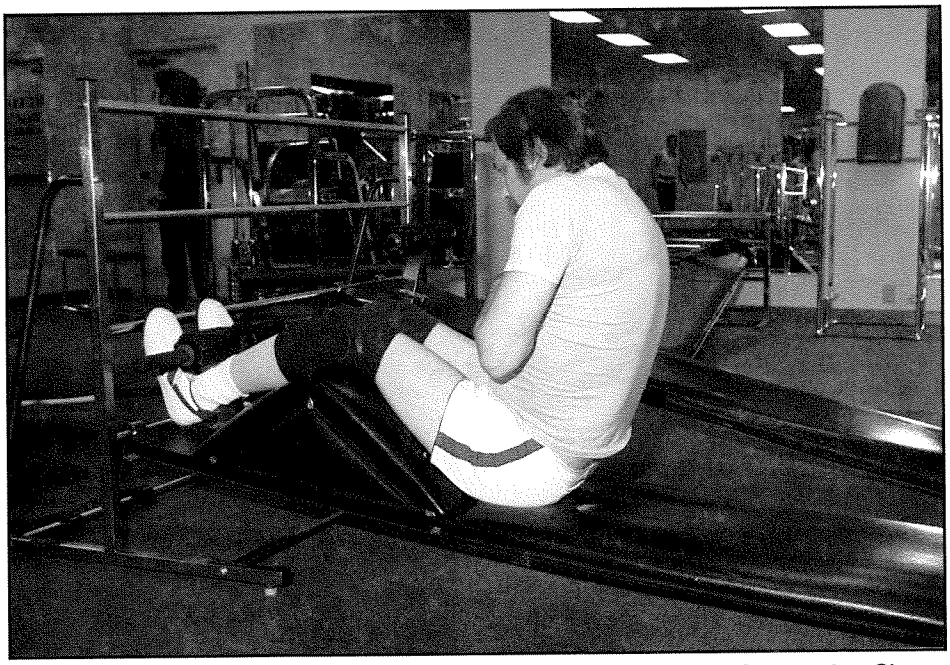
SKILL LEVEL
Intermediate.

NOTE

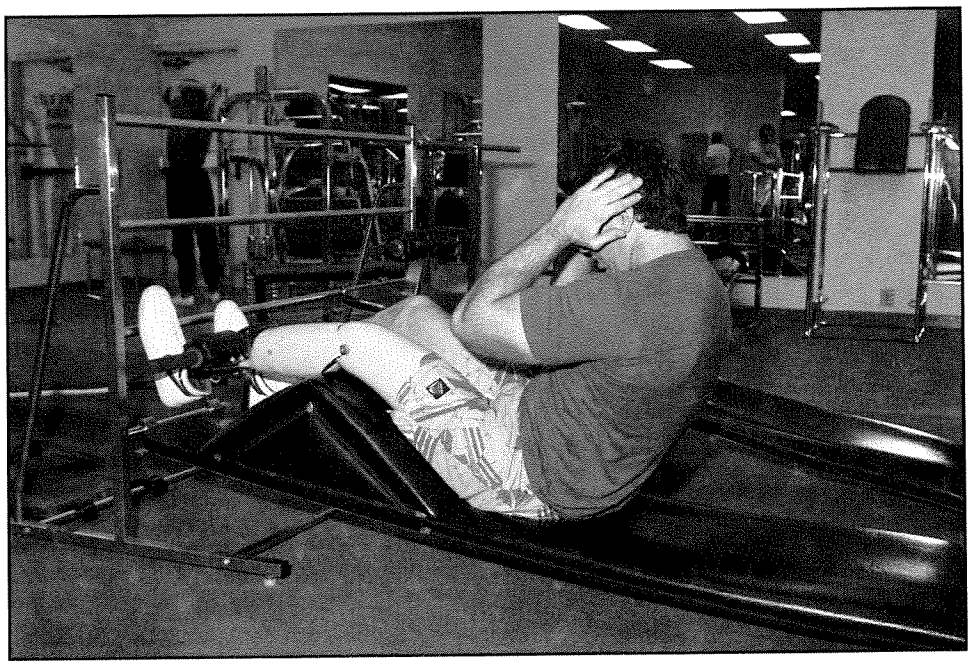
The greater the angle of the bench, the more difficult the sit-up. Beginners should start with the lowest angle. Two types of adjustable incline benches are shown. The incline bench shown in the first two photos supports the bent leg at a 45-degree angle. A more advanced incline bench with no bent-leg support is shown in the latter two photos.

CAUTION

If you have back problems, keep the lower back on the bench and raise your body no further than a half sit-up. Raise the head and shoulders only as high as is comfortable.

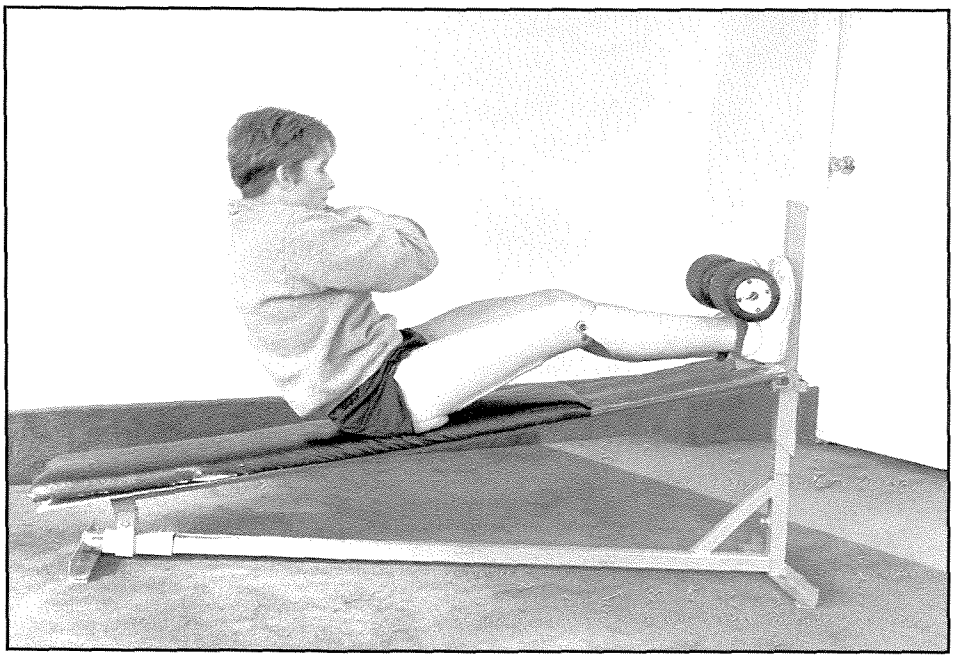


John Everett performs an Incline Bench Sit-up using ActivSleeve Suspension Sleeve with exoskeletal prostheses and Seattle Feet.

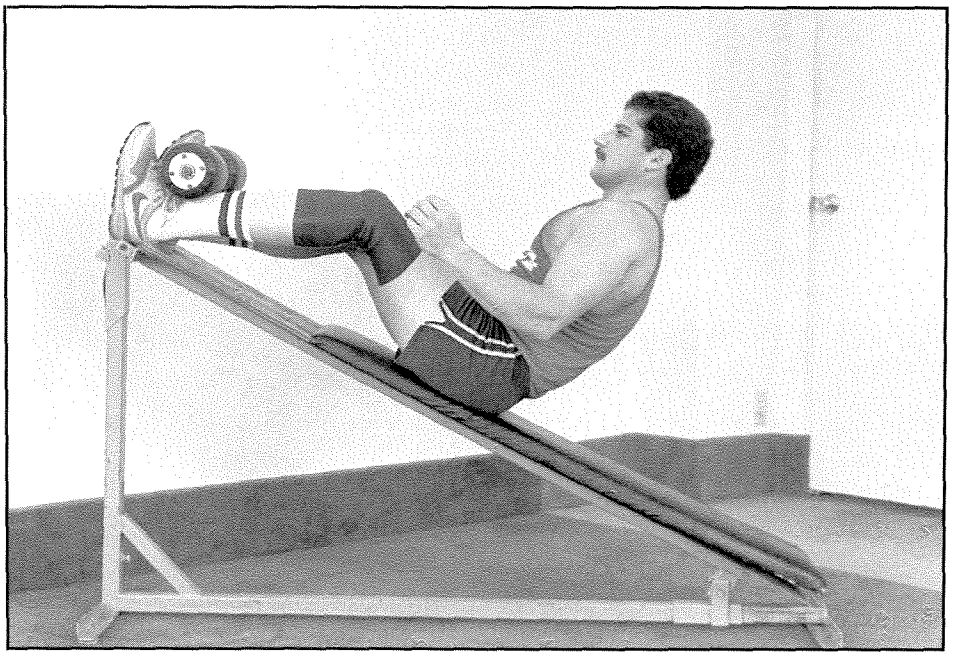


Mike Nitz performs an Incline Bench Sit-Up using the Flex-Foot.

EXERCISE 57. INCLINE BENCH SIT-UP WITH VARIATIONS (Continued)



Linda Pedersen demonstrates a sit-up on an incline bench with no bent-leg support. She is using the Exoskeletal Quad Suction Socket, Mauch SNS Knee Unit, and Otto Bock SACH Foot.



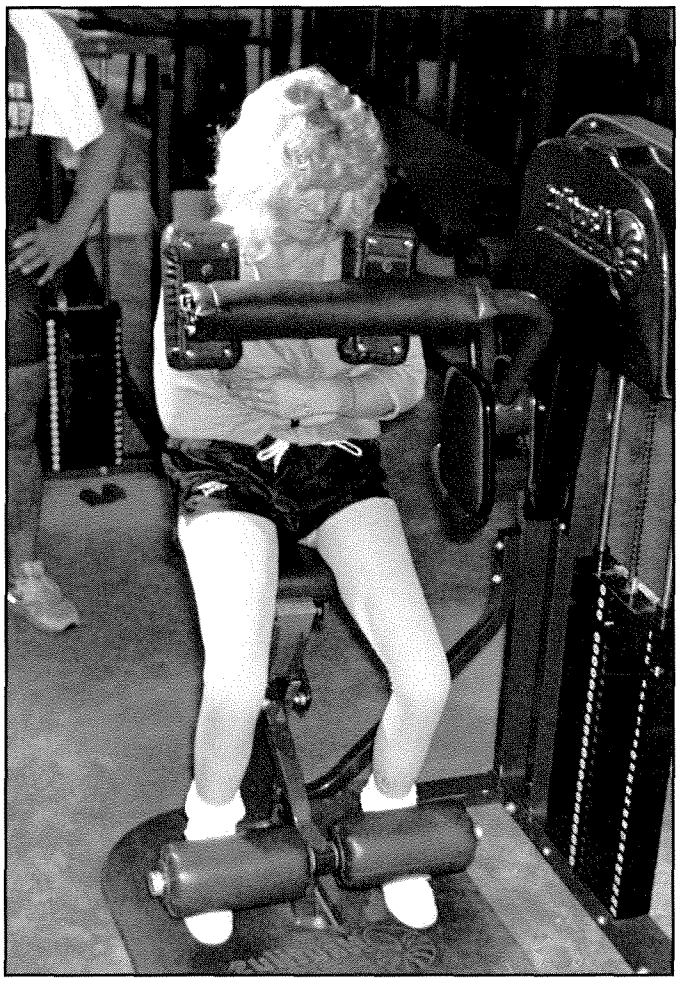
Albert Rappoport demonstrates an Incline Bench Sit-Up with the bench raised to its maximum position for greater difficulty.

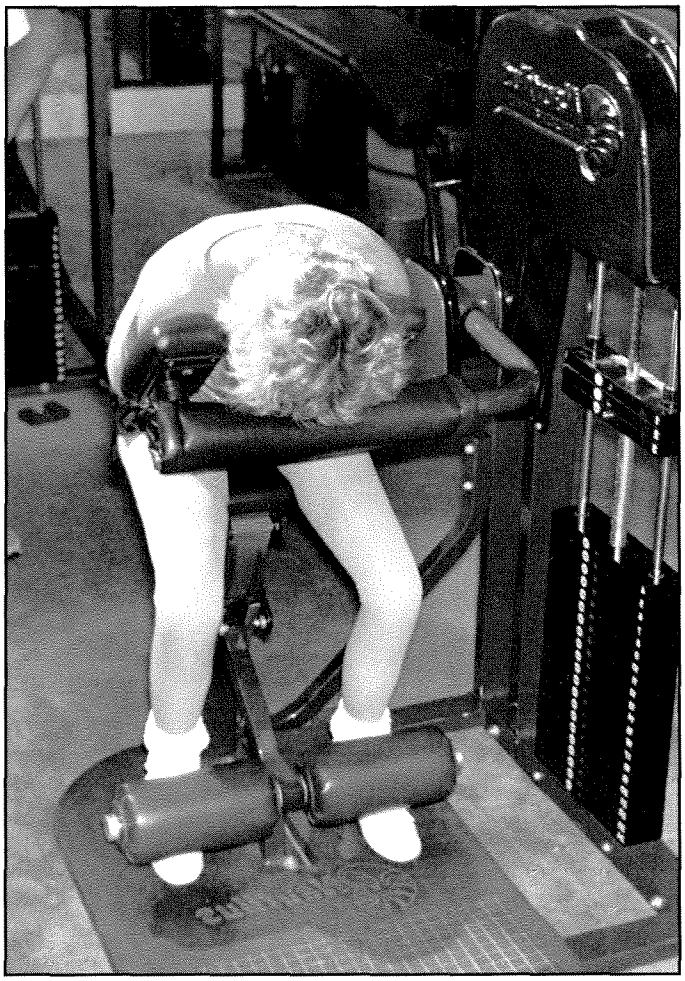
EXERCISE 58. NAUTILUS ABDOMINAL CHAIR

PURPOSE
Strengthens the abdominal muscles and hip flexors.

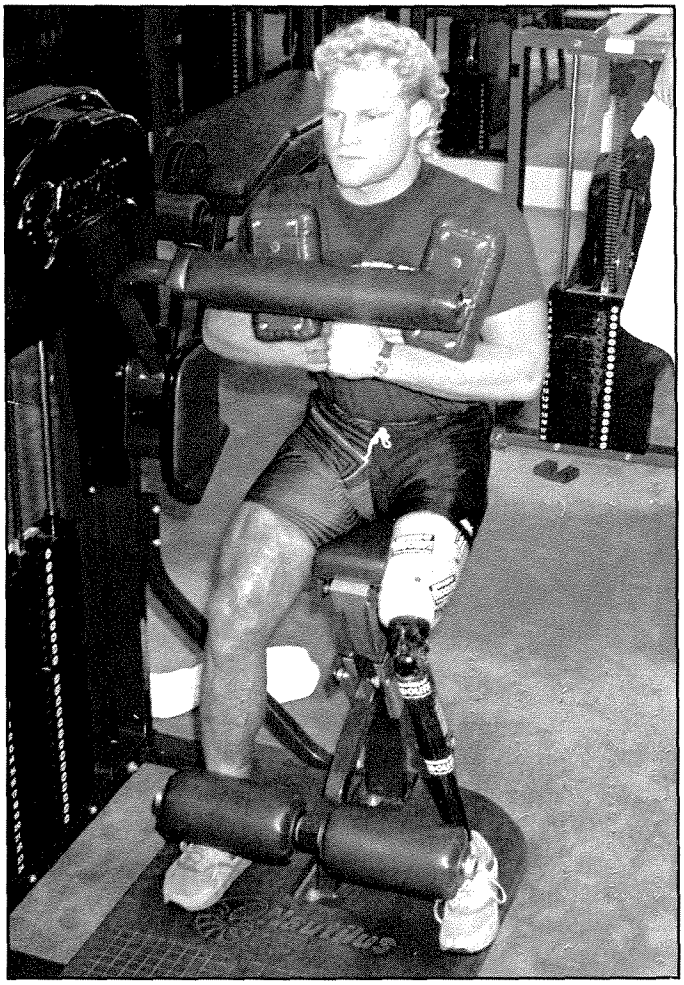
PROCEDURE
- Sit on the bench and place your feet beneath the ankle pads. Sit straight and position the upper pads so that you can press against them with your shoulders, upper arms, and chest.
- Cross your arms in front of your chest.
- Bend from the waist and push down against the upper pads as far as possible.
- Flex your trunk from the waist, moving your upper body forward and down.
- Pause momentarily, then slowly let yourself back up to the starting position.

SKILL LEVEL
Beginner.


Samantha Ellis demonstrates the starting position.


Ellis pauses before returning to the starting position.

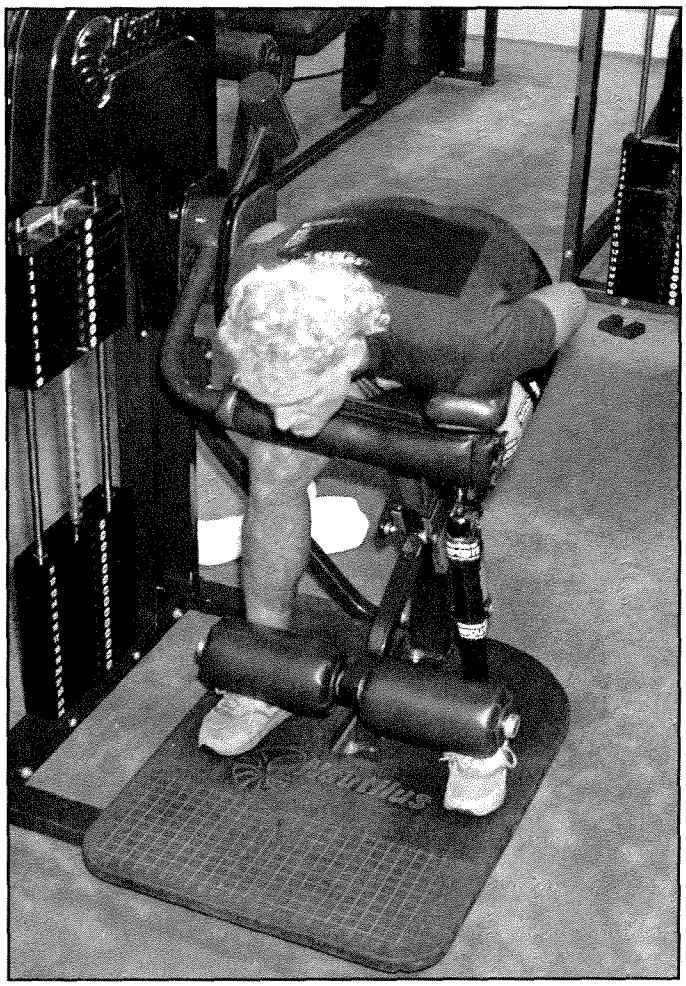
EXERCISE 58. NAUTILUS ABDOMINAL CHAIR (Continued)



Greg Mannino in the starting position for exercise.

NOTE

The Nautilus chair places little stress on the back and resistive weight increases the effectiveness of the exercise. Another advantage of this chair is that an assistant is not needed to hold the legs down.



Mannino in the finish position.

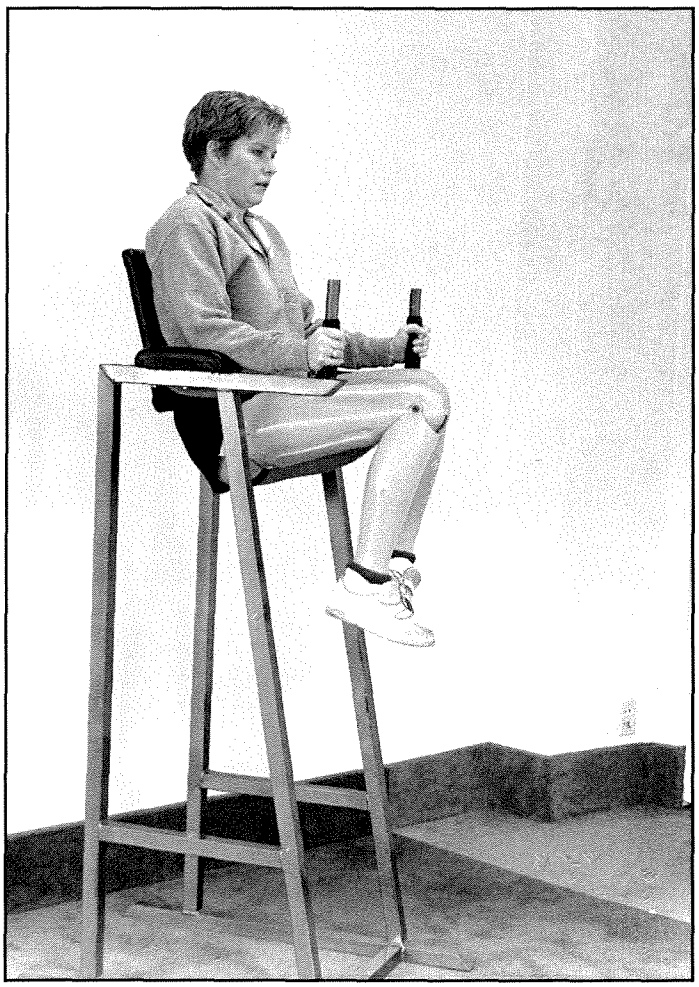
EXERCISE 59. VERTICAL BENCH BENT-KNEE RAISE

PURPOSE
Develops the lower abdominal muscles and hip flexors.

PROCEDURE
- Place your forearms against the pads of the vertical bench and lock your shoulders out to help support your body weight.
- Keep your back against the back rest. Let your legs hang in a vertical position and then bend your knees and bring them up to waist level or slightly higher.
- Exhale as you raise your legs and inhale as you lower them. Straighten the legs as they are being lowered.
- When bringing your legs up, try not to swing your body. Keep your back against the back rest and use only the abdominal muscles to raise the legs.

MODIFICATION
The sound leg may be pressed against the prosthesis to maintain its position and aid in lifting it.

SKILL LEVEL
Intermediate.



Linda Pedersen pauses before lowering her legs to the starting position.

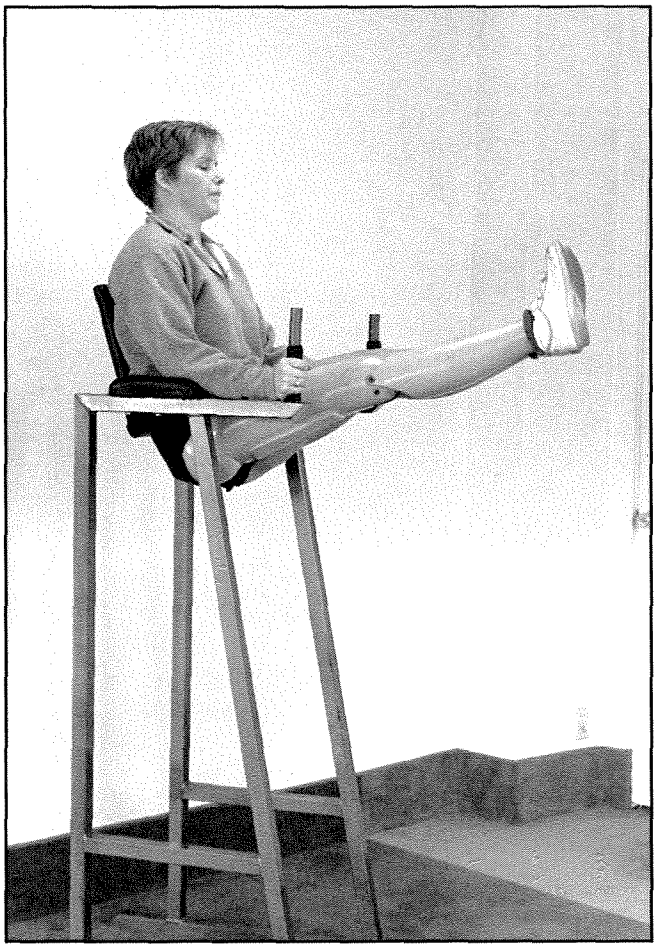
EXERCISE 60. VERTICAL BENCH STRAIGHT-LEG RAISE

PURPOSE
Develops the lower abdominal muscles and hip flexors.

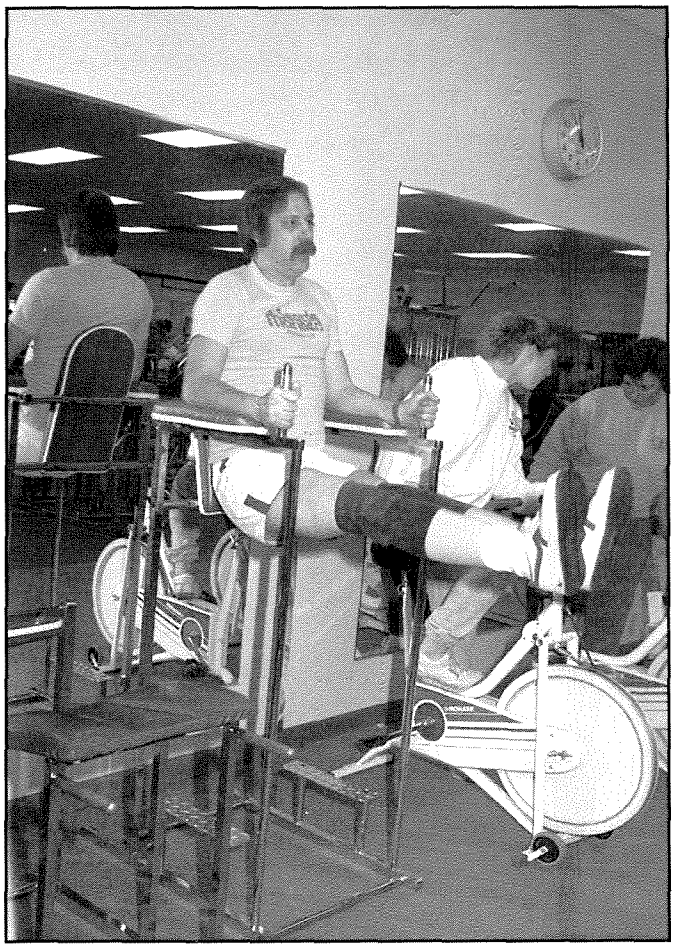
PROCEDURE
- Place your forearms against the pads of the vertical bench and lock your shoulders out to help support your body weight. Keep your back against the back rest.
- Starting with the legs in the vertical position, bring them up with knees straight until the legs are parallel to the floor or slightly higher. Hold the position momentarily before lowering the legs, making each repetition more challenging.
- Exhale as the legs are raised and inhale as they are slowly lowered to the starting position. Try to keep your back against the back rest and concentrate on using only the abdominal muscles to lift the legs.

MODIFICATIONS
Individuals using an AK prosthesis without a locking knee unit that locks, should keep the sound limb underneath the prosthesis at the heel or keep the legs pressed tightly against each other to prevent the prosthetic knee from flexing and to aid in lifting the prosthesis. Good prosthetic suspension is important. Linda Pedersen uses a quadrilateral suction socket with a Hosmer Red Dot valve. John Everett uses ActivSleeves with a small USMS Adjustable Leak Rate Valve to create suction type suspension. If the exercise is too difficult to complete, raise your legs only part way or use Exercise 61 until you build up adequate strength.

SKILL LEVEL
Intermediate.



Linda Pedersen demonstrates the Straight-Leg Raise. Her Mauch SNS Knee Unit is locked in an extended position so that the knee will not flex.



John Everett does the Straight-Leg Raise on a different type of vertical abdominal bench. He keeps his legs up by extending his knees and pressing his heels together.

EXERCISE 61. INCLINE LEG RAISE

PURPOSE
Strengthens the lower abdominal muscles and hip flexors.

PROCEDURE
- Adjust the incline bench to about a 25-30 degree angle. Position your head at the top of the bench and grasp the bar behind your head with both hands.
- Keep your legs straight and together. Inhale as you raise both legs to at least a vertical position above the hips.
- Keep tension on the abdominal muscles at all times. This may mean not bringing the legs all the way up and not letting the heels rest on the bench when you lower them.
- Do not hold a position or rest during the exercise. While exhaling, lower the legs until they are about 3 inches off the bench. Bring the legs back up and repeat the exercise.

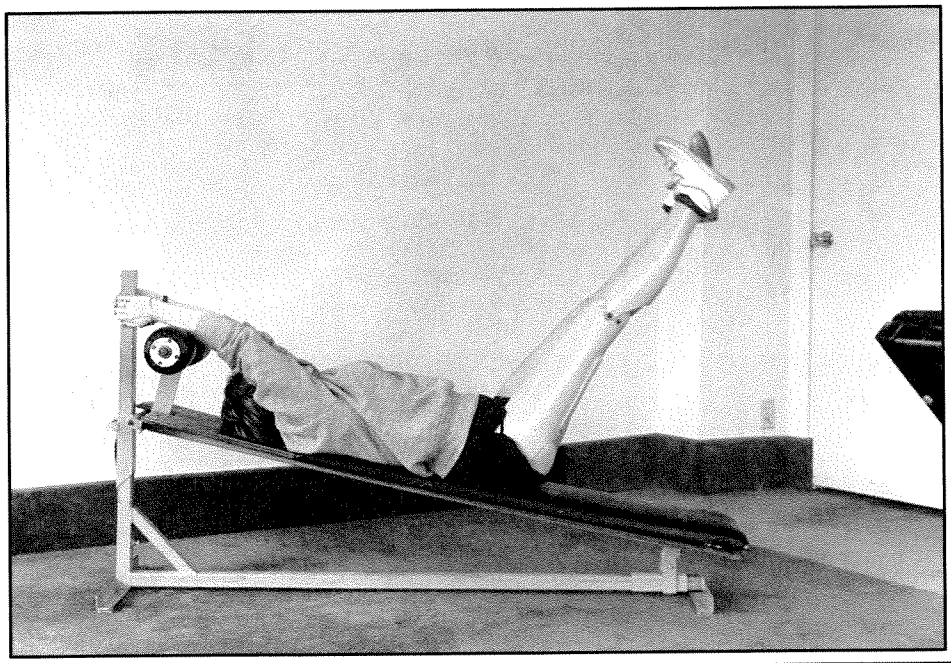
VARIATION
If you wish to include working your oblique muscles, perform one repetition with legs straight as you raise them; the next by twisting your hips as you raise your legs toward your right shoulder, bring legs straight back toward your head, down, and then to the left shoulder. Repeat the sequence, starting with the legs in the center.

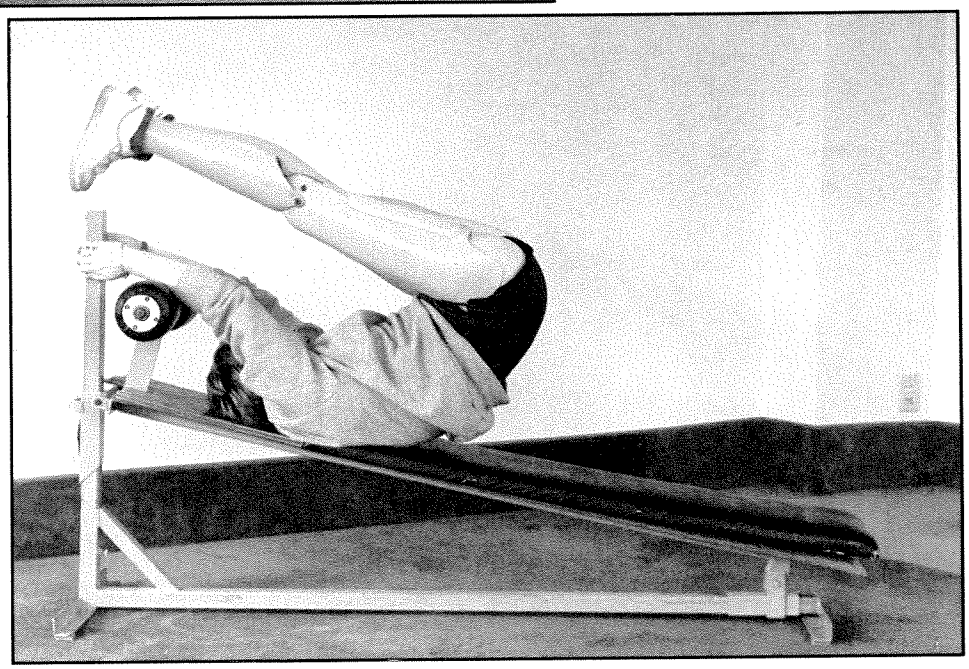
MODIFICATION
If you are working with a knee unit on an AK prosthesis that does not lock in an extended position, keep the sound limb under the prosthesis at the heel in order to lift it and to maintain a straight knee.

SKILL LEVEL
Advanced.

CAUTION

For those who experience low back pain, the knees can be bent as the legs are raised and straightened as the legs are lowered. Keep the lower back in contact with the bench at all times.





Linda Pedersen demonstrates the Incline Leg Raise.

EXERCISE 62. SIDE BENDS WITH DUMBBELL

PURPOSE

Strengthens the internal and external oblique and erector spinae muscles. Limbers and firms the muscles underlying the "love handles."

PROCEDURE

- Stand with your feet about shoulder-width apart.
- Hold the dumbbell in one hand and place the other hand behind your head (or on your waist if you need stability at first).
- Stand erect and bend to the side at the waist (straight over the hips).
- Return to the starting position. Keep your back straight and do not bend at the hips or knees, only from the waist. Continue the exercise in this manner, bending as far as possible from side to side.
- Change arm and dumbbell positions and bend again from side to side.
- Work up to 15-20 repetitions per side before a rest period. Gradually increase the number of sets to three or four per side.

MODIFICATION

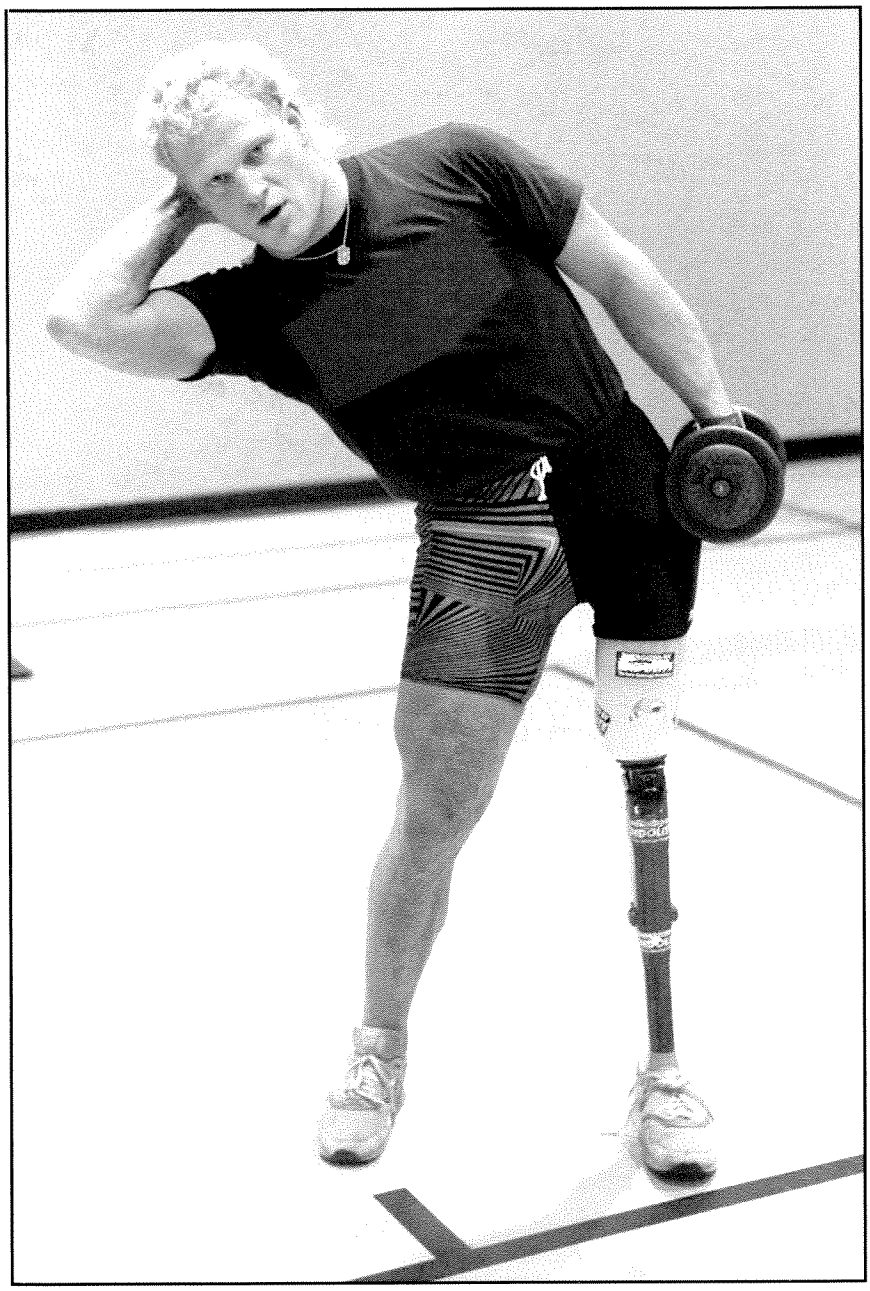
The exercise may be performed sitting down.

SKILL LEVEL

Beginner.

NOTE

Beginners should perform this exercise without the dumbbells for the first several workouts. Start with a lightweight dumbbell and work up to heavier weights. Do not lift weights that prohibit 15-20 repetitions. Try beginning with 5 pounds and increase the weight by 5 pounds at a time. Concentrate on performing more repetitions, not on lifting heavier weights. You want to tone the obliques and waistline, not add muscle bulk.



Greg Mannino demonstrates the exercise.

EXERCISE 63. SIDE BENDS/HYPEREXTENSION BENCH

PURPOSE
Strengthens the internal and external oblique muscles.

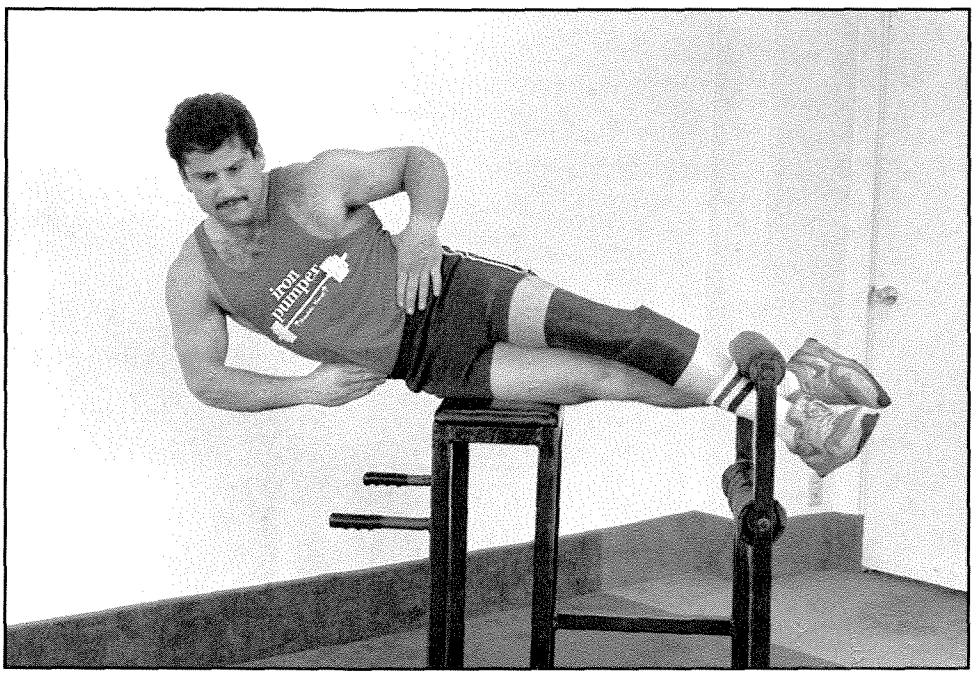
PROCEDURE
- Position yourself on your side on the seat of the hyperextension bench while crossing your legs underneath the adjacent bar for support.
- Lower your trunk as far as possible.
- Bring your trunk to the highest upright position while remaining on your side.
- Legs can be switched and the body turned around so that both sides can be worked.

MODIFICATIONS
If this position is too difficult, you may work the internal and external obliques while standing or sitting by bending side-to-side or twisting the trunk (see Exercise 62). Holding a dumbbell or weight plate in one hand for increased resistance can be effective.

SKILL LEVEL
Advanced.

NOTE

The position is difficult to assume and maintain, particularly on the first try. While learning this exercise, you should always be assisted by a spotter.



Albert Rappoport uses the ActivSleeve Suspension System to provide the necessary support.

EXERCISE 64. STRAIGHT-LEG SIT-UP/HYPEREXTENSION BENCH

PURPOSE
Works the upper abdominals and hip flexors.

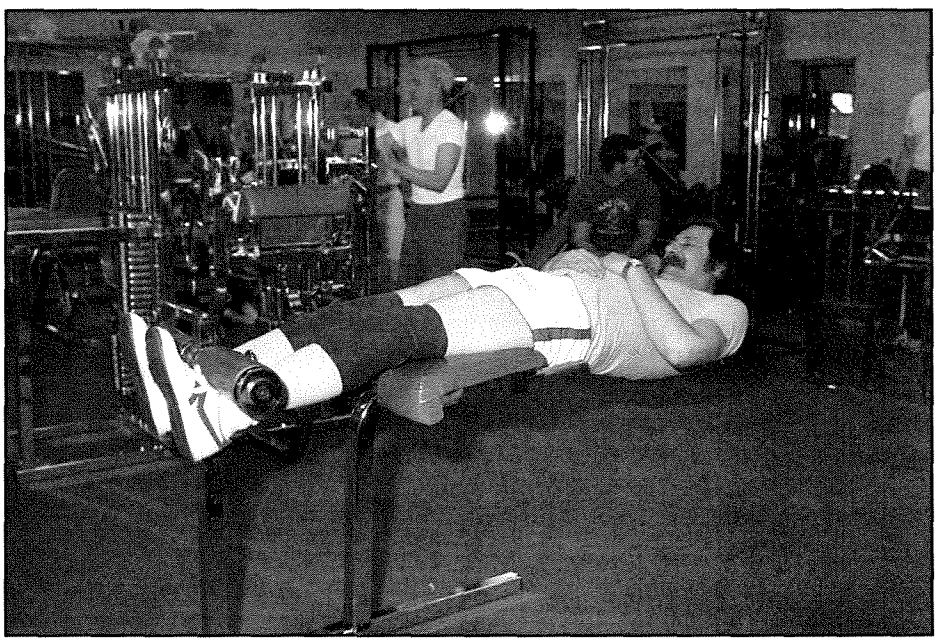
PROCEDURE
- Sit on the hyperextension bench and position your feet underneath the bar for support.
- Bend backward until your upper body is lower than the bench.
- Perform a sit-up by raising yourself back to an upright position using only the abdominal muscles.
- Do not bend too far forward when you return to the upright position because that will lessen the tension on the abdominal muscles.

MODIFICATIONS
ActivSleeve Suspension Sleeves create a suction-type suspension which imparts confidence that the legs will not displace, especially for those with bilateral amputation. Seattle feet are used on the exoskeletal prostheses with New Life Laboratories PM Liner and New Skin cosmetic covering.

SKILL LEVEL
Advanced.

NOTE
This exercise is particularly challenging because it is difficult to get into the starting position on the hyperextension machine.

CAUTION
This exercise places great stress on the lower back. Avoid in the presence of any back problems.



John Everett performs an advanced variation of the sit-up exercise.

EXERCISE 65. EXERCISE WHEEL

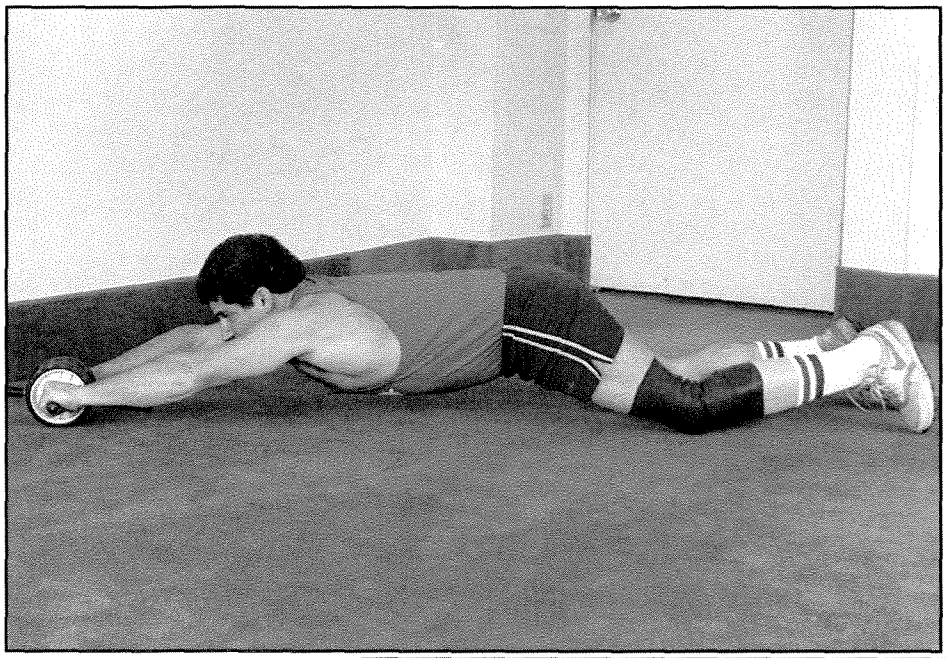
PURPOSE
Strengthens the abdomen, shoulder extensors, and hip flexors.

PROCEDURE 1: BEGINNING POSITION (KNEES ON GROUND)
- Lie face down on an exercise mat.
- Starting with the knees on the ground, grab the handles on either side of the exercise wheel and roll it out in front.
- Slowly extend the arms and stretch the body out straight until the back is at least parallel to the ground. Keep the wheel in contact with the ground at all times.
- Bring the body to an upright position. No part of the body from the knees up should be in contact with the floor. Hold the extended position for a few seconds.
- Increase the hold time by a few seconds each time you do the exercise in order to build strength in the abdomen and lower back.
- Repeat 5-10 times for each set; three sets are recommended.

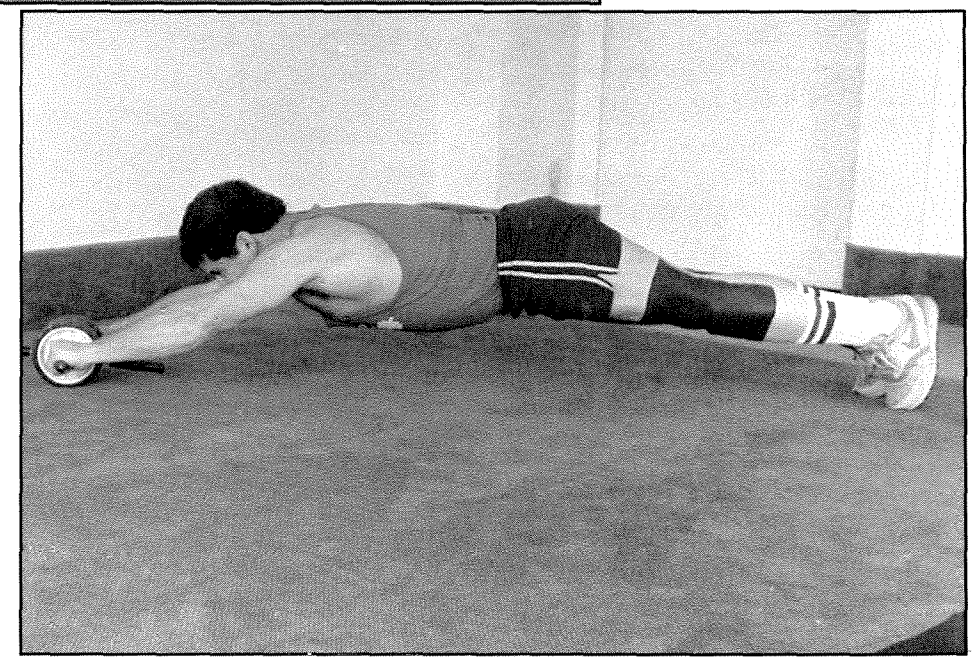
PROCEDURE 2: ADVANCED POSITION (KNEES OFF GROUND)
- Begin from a standing position.
- Place the exercise wheel on the floor and roll it forward.
- Extend the legs and arms as the body is lowered to an outstretched position, as seen in the photo. No part of the body may touch the ground.
- Raise the wheel and body back to a standing position while legs and arms continue to be extended.
- The wheel remains in contact with the floor until it reaches the toes. The body is now upright and the exercise may be repeated.
- Repeat 3-5 times for each set; three sets are recommended.

MODIFICATION
A foot with a keel extending out to the toes is helpful in maintaining balance.

SKILL LEVEL
Intermediate to Advanced.



Albert Rappoport demonstrates Procedure 1, Beginning Position: starting from the knees.



Rappoport demonstrates Procedure 2, Advanced Position: starting from the feet with the knees never touching the floor.

11

CHEST

Well-developed chest muscles provide endurance. People who use wheelchairs or who are otherwise limited in their mobility will tire less easily when moving about if they develop upper-body strength. The same is true for those who participate in recreational or competitive sports. Men who are interested in having a powerful physique need to concentrate on exercises that develop the chest and arms. Women will benefit from chest exercises that build muscles to strengthen and support the underlying tissues of the breasts.

The upper torso is supported by 12 pairs of ribs attached to the sternum and covered by the pectoralis major and minor muscles. The most important chest muscles are the pectoralis major, which are attached to the sternum at one end and to the upper arm at the other. These are the muscles most commonly referred to when discussing chest development because they support and stabilize the upper torso, including the shoulders.

It is difficult to isolate the chest muscles for conditioning because the exercises also involve movements of the triceps and shoulders. Since the triceps are much smaller than the pectoralis, they become fatigued by the exercise before the chest muscles can get a full workout. The larger muscles are usually worked first in order to prevent the fatigue of the smaller muscles, which in turn would limit the working of the larger muscles. However, there are exercises done with machines that can isolate the chest muscles; in particular, those done on the Fly Deck machine.

There are many chest exercises that can be used in a workout program for the person with AK or BK amputation. If a prosthesis is not worn, exercises may be done when seated on a Nautilus, Universal, or Paramount machine. These machines do not require standing balance. Exercising with free weights may also be done from a seated position. However, if you do choose to lift free weights while not wearing your prosthesis, assistance should be available, particularly if you must ambulate with crutches or a wheelchair. The simple task of moving the weights across the room is difficult, not to mention setting up the barbell for each exercise. These considerations should be taken into account when setting up your program.

CHEST EXERCISE ROUTINE		
Muscle	**Exercise**	**Title**
Warm-up/Pectorals/Triceps	66	Beginning Push-ups
Warm-up/Pectorals/Triceps	67	Standard Push-ups
Warm-up/Pectorals/Triceps	68	Alternating One-handed Push-ups
Pectorals	69	Shoulder Adduction
Upper/Inner Pectorals	70	Nautilus Bent-arm Fly
Pectorals/Anterior Deltoids/Triceps	71	Nautilus Bench Press
Upper Pectorals	72	Double Pulley Cross
Pectorals	73	Bench Press
Pectorals/Anterior Deltoids/Triceps	74	Standing Incline Press
Pectorals/Triceps	75	Decline Press
Pectorals/Serratus Anterior/Triceps	76	Parallel Bar Dips

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

EXERCISE 66. BEGINNING PUSH-UPS

PURPOSE

Warm-up exercise for the upper body and arms, particularly the pectorals and triceps. Push-ups also are a form of endurance conditioning as the number of successive repetitions is increased.

PROCEDURE

- Lie face-down on the floor.
- Place your hands on the floor a bit below shoulder level with the elbows bent.
- Lift your body from the knees up, until your arms are fully extended.
- The knees should remain on the floor. Slowly return to the starting position. By lowering yourself very slowly you can double the benefits of the exercise.

MODIFICATIONS

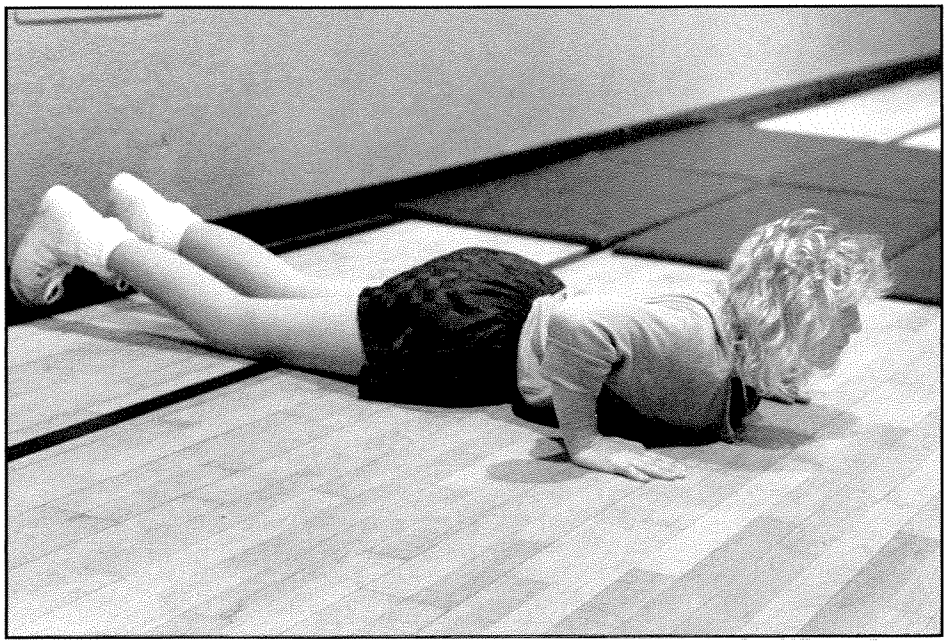
For those with bilateral amputation, using the support of a wall helps to maintain stability. The person with bilateral AK amputation will always have the knees in contact with the floor unless knees are manually locked in extension.

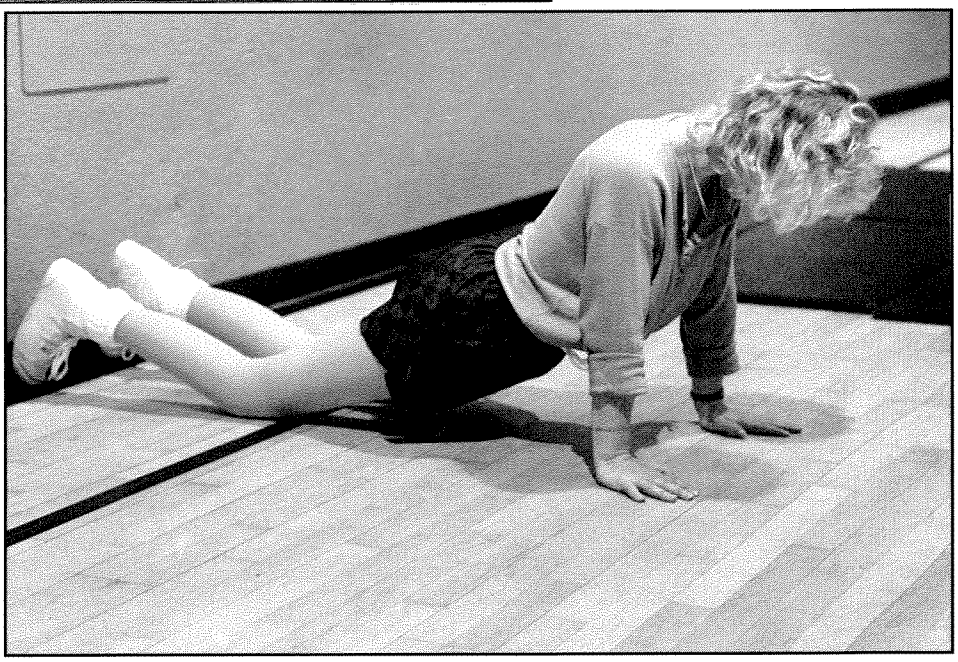
SKILL LEVEL

Beginner.

CAUTION

This exercise can be stressful to the lower back. Omit if low back problems are present.





Samantha Ellis uses the wall for support and stability.

EXERCISE 67. STANDARD PUSH-UPS

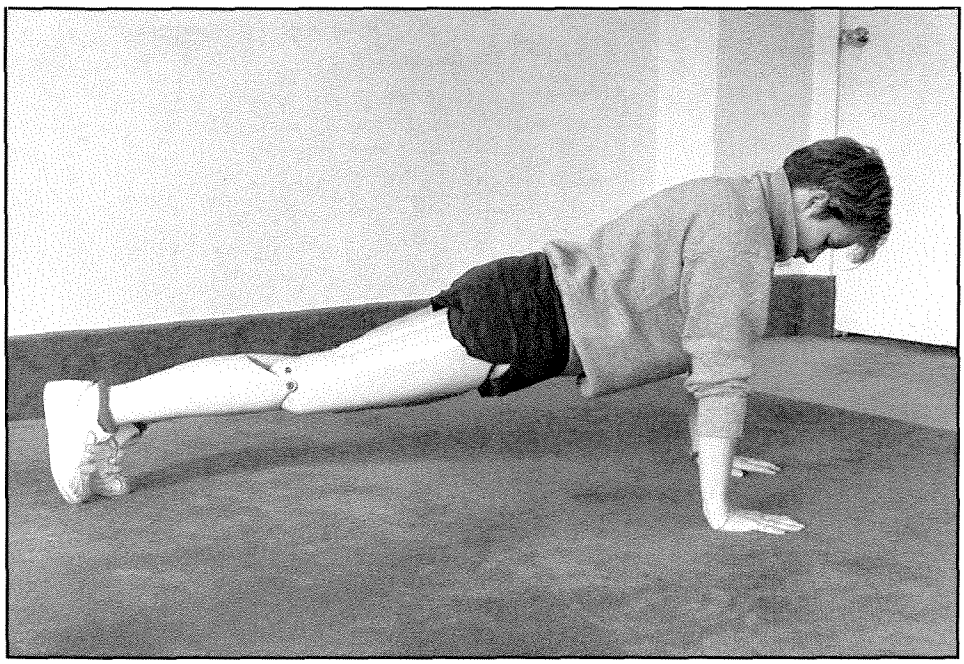
PURPOSE
Warm-up for the upper body and arms, particularly the pectorals and triceps. Push-ups also are a form of endurance conditioning as the number of successive repetitions is increased.

PROCEDURE
- Begin in the "up" position. Hand position can vary but should be at least slightly wider than the shoulders.
- Keep the elbows close to your body and lower yourself very slowly.
- Keep your back straight and do not allow the knees to touch the floor.
- Lower to within 1-2 inches of the floor and pause momentarily. Keeping your back straight, slowly raise your body to the "up" position.
- Inhale while lowering and exhale while raising yourself back to the starting position. By placing your hands wider apart, you will be able to work more of the outer pectoral muscles.

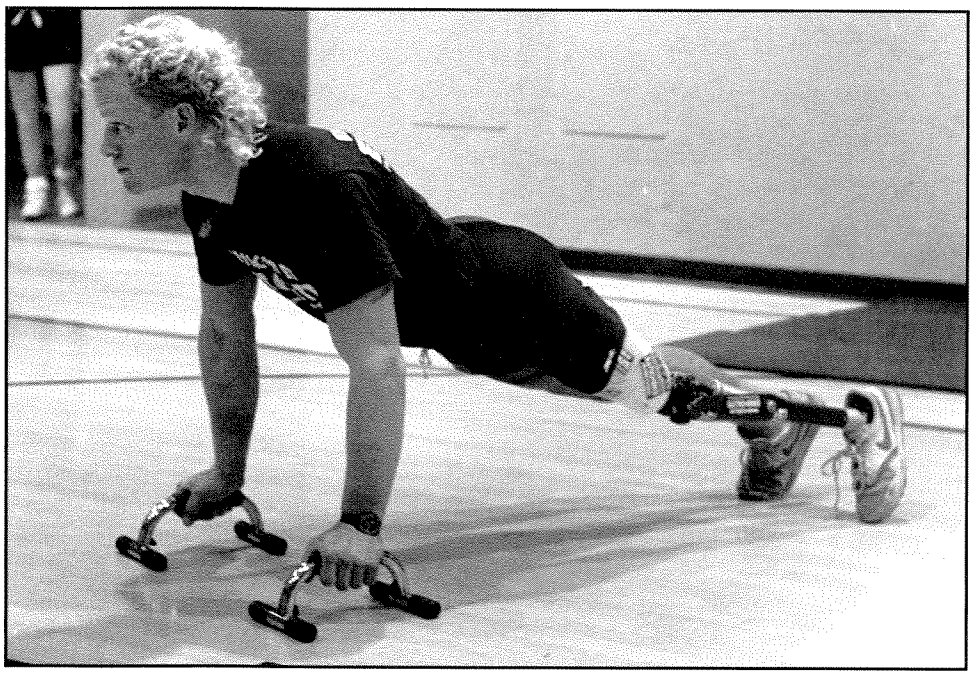
VARIATION
Use push-up handles to lower yourself further for a fuller range of motion.

MODIFICATION
In most cases, those with AK prostheses will need knee-lock capability.

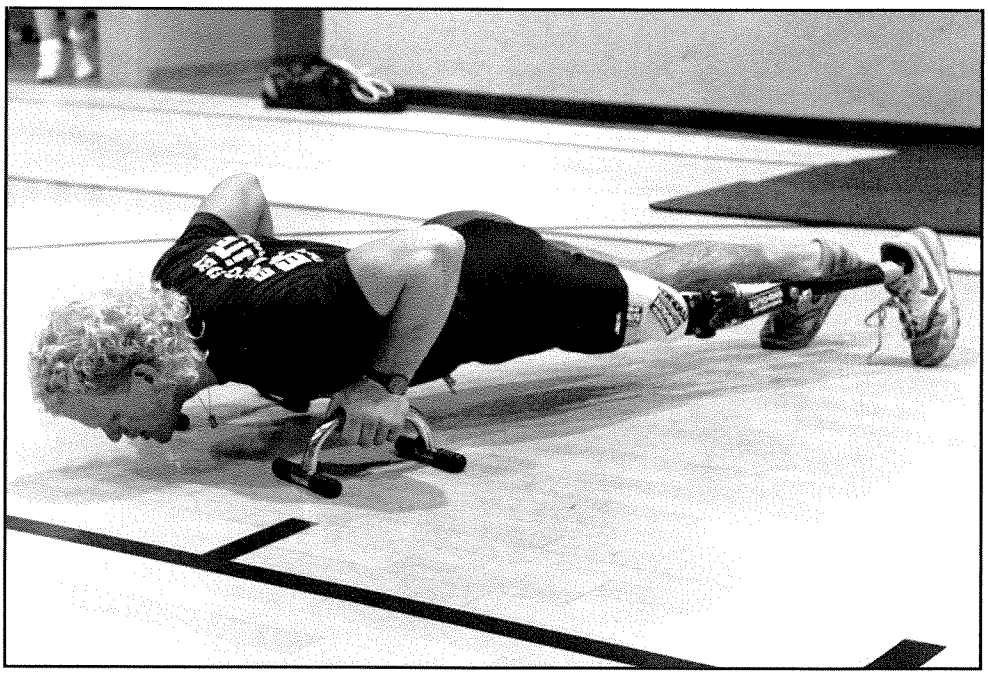
SKILL LEVEL
Intermediate.



Linda Pedersen begins the exercise in the "up" position.



Greg Mannino uses the push-up handles.



EXERCISE 68. ALTERNATING ONE-HANDED PUSH-UPS

PURPOSE

Builds strength in the arms, upper body and, to a lesser degree, the abdominal muscles. This difficult exercise is also used by athletes for strength conditioning.

PROCEDURE

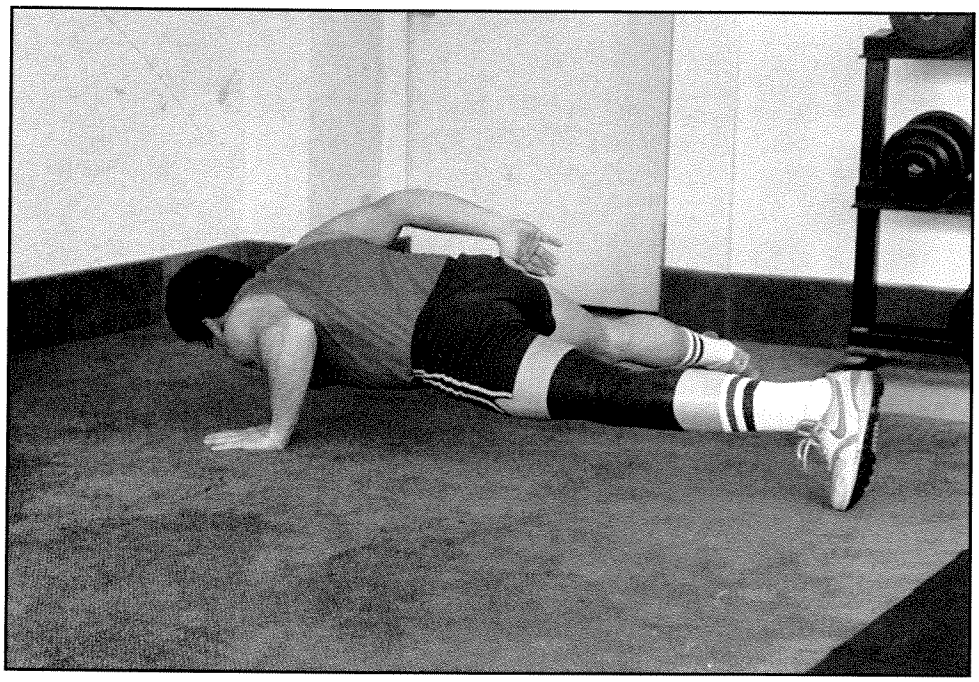
- Feet are spread as wide apart as is necessary to maintain stability. The supporting hand should be close to the body as the push-up is performed.
- The chest and knees should not touch the floor and the other arm will naturally be held up and away from the floor.

MODIFICATIONS

Good socket suspension is necessary, as well as a prosthetic foot which has a keel that extends through the end of the toe section.

SKILL LEVEL

Advanced.



The exercise is performed by Albert Rappoport.

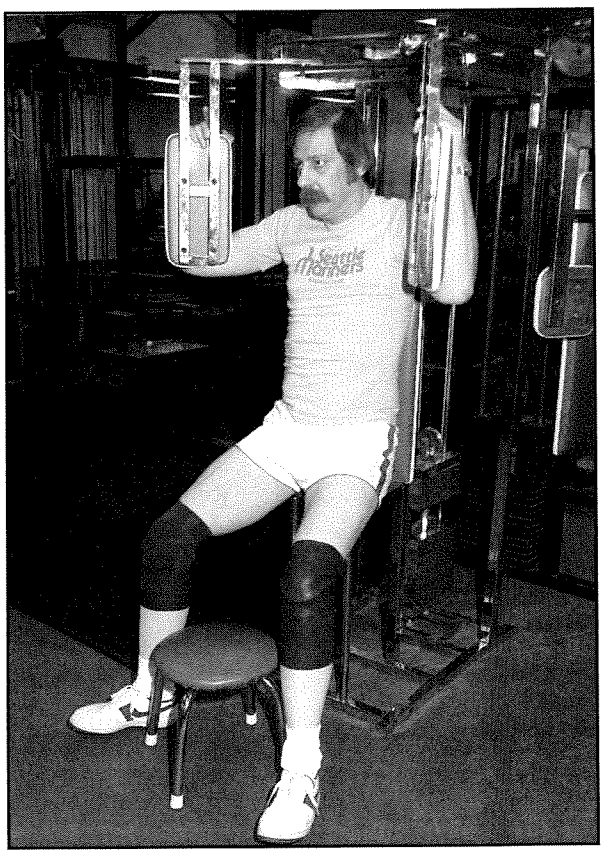
EXERCISE 69. SHOULDER ADDUCTION

PURPOSE
Develops the portion of the pectorals near the sternum.

PROCEDURE
- Feet should be placed comfortably on the floor, making it easy to push against the ground for stability. (A seat belt helps to reduce excess body movement and isolate and exercise the chest muscles.) The upper arms should be in line with the shoulders.
- Begin with the upper arms parallel to the floor and outstretched to the side midline to the body, or behind the midline for a better stretch.
- Bring the forearms together in a controlled movement. Do not slam the two pads into each other. The arms naturally tend to drop slightly as the forearms are brought together.
- Allow the forearm pads to return slowly to their starting position.
- Breathing techniques can vary, but you should either inhale or exhale on each movement. Many individuals find it easier to exhale on the concentric contraction of bringing the forearms together and then inhale on the eccentric contraction of returning to the start position. Do not squeeze your hand grip because this detracts from the workout of the chest muscles by using extra energy.

MODIFICATION
On the Paramount or Universal machines, the feet provide a slight amount of counter pressure for balance while performing the exercise. Thus, a person exercising without a prosthesis may feel more comfortable using the Nautilus Bent-Arm Fly Machine (Exercise 70). On the Nautilus, the feet are completely off the ground. The body is balanced with an angled bench and seat belt.

SKILL LEVEL
Intermediate.



John Everett demonstrates the pectoral press on the Paramount Fly Deck Machine. A variety of machines are available from Nautilus, Paramount, and Universal. These machines vary slightly with different adjustments for seat and arm positions, but all work the chest muscles in the same general manner.

EXERCISE 70. NAUTILUS BENT-ARM FLY

PURPOSE

Develops the upper and inner pectoral muscles.

PROCEDURE

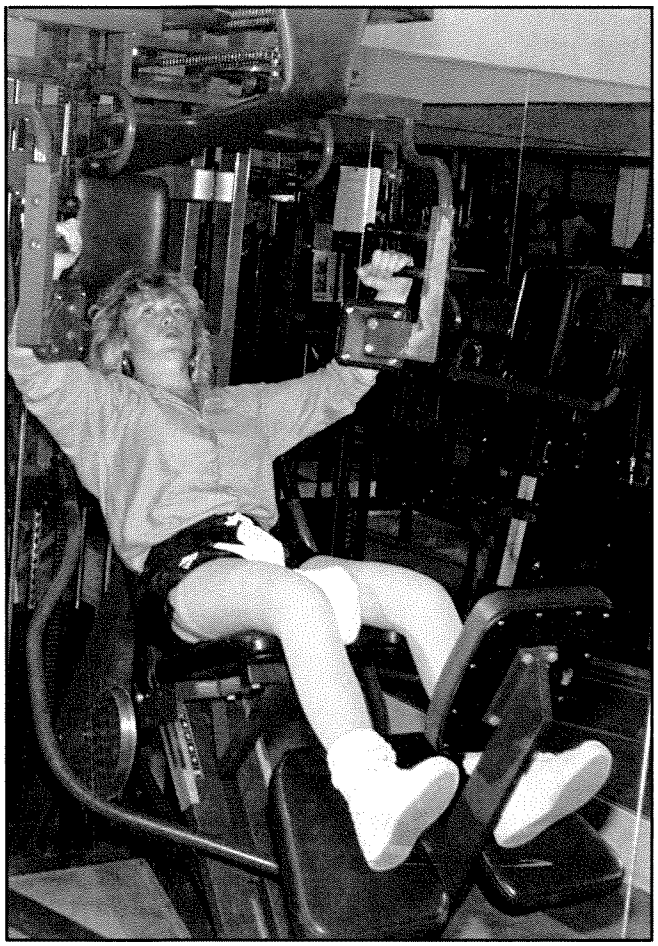
- Sit down and adjust the seat so your shoulders are directly under the hand grip overhead.
- Fasten the seat belt, place your forearms behind the pads, and grip one of the hand bars, making sure that your thumbs are under the bar.
- As an option, the upper hand grip will give a greater stretch and fuller range of motion.
- Bring your forearms together across the mid-line of your body.
- Exhale as you bring your arms together and inhale as you slowly return them to the starting position.

SKILL LEVEL

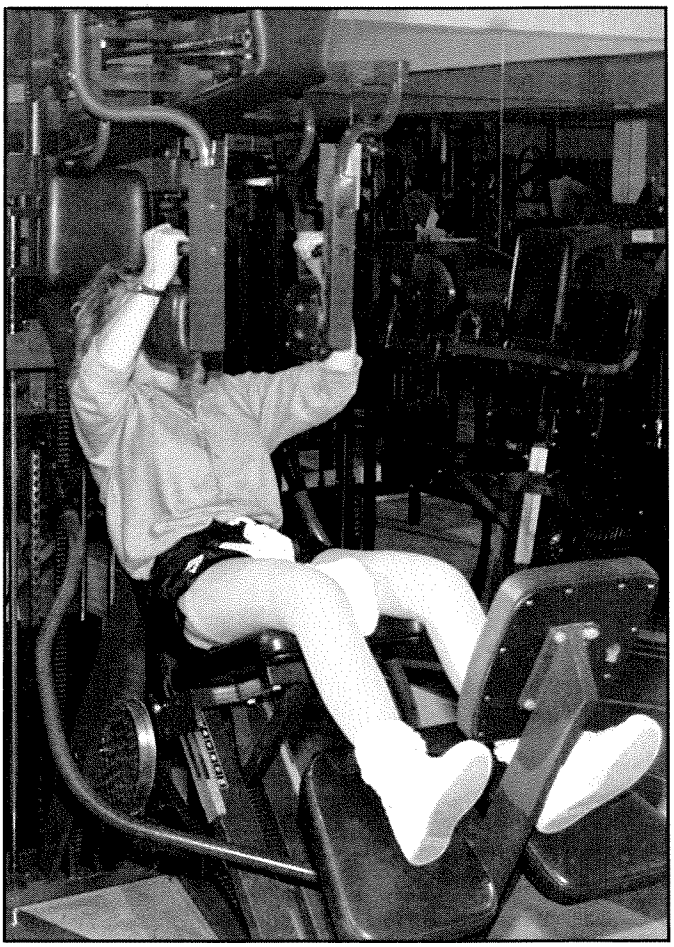
Intermediate.

NOTE

This exercise is similar to the Shoulder Adduction (Exercise 69), but the Nautilus machine works the pectorals from a slightly different angle, allowing you to achieve a greater stretch while lifting. This Nautilus machine incorporates the Bench Press exercise (Exercise 71).



Samantha Ellis demonstrates the exercise.



EXERCISE 71. NAUTILUS BENCH PRESS

PURPOSE

Develops the pectoral, anterior deltoid, and triceps muscles.

PROCEDURE

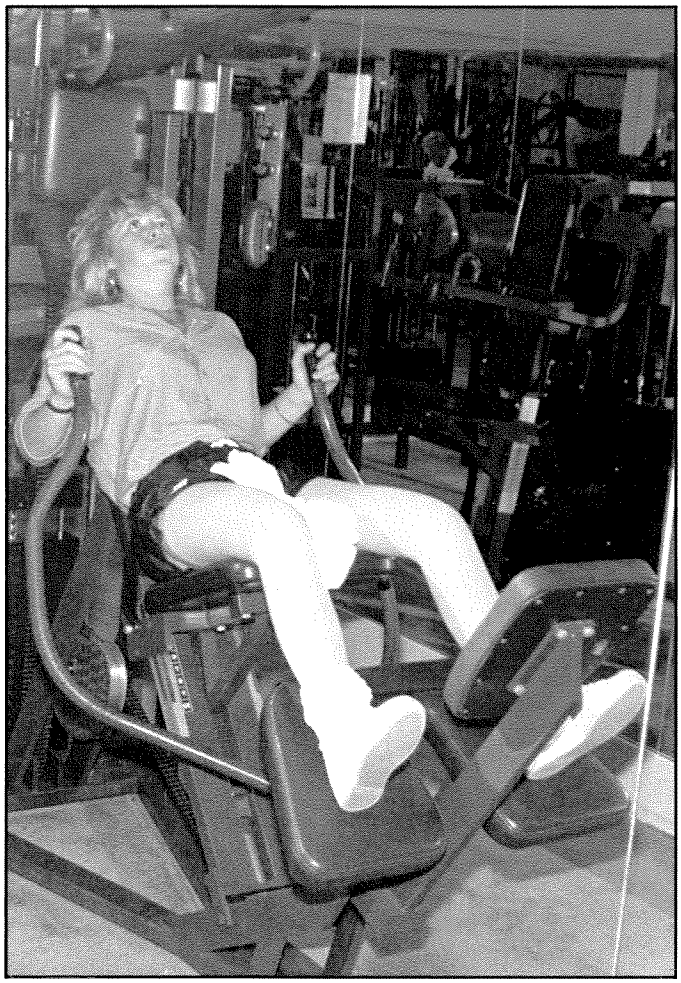
- Position the sliding seat so that the shoulders are directly beneath the grab handles. The hands should be level with the widest part of the chest.
- Fasten the seat belt and sit back.
- Take hold of the hand grips firmly, but do not squeeze them. Keep your elbows up and wide, and near the same height as your shoulders. Your forearms should be parallel to the floor.
- Exhale as you push the bar away from your body until the elbows are fully extended.
- Pause for a moment before allowing the bars to return to the starting position.

SKILL LEVEL

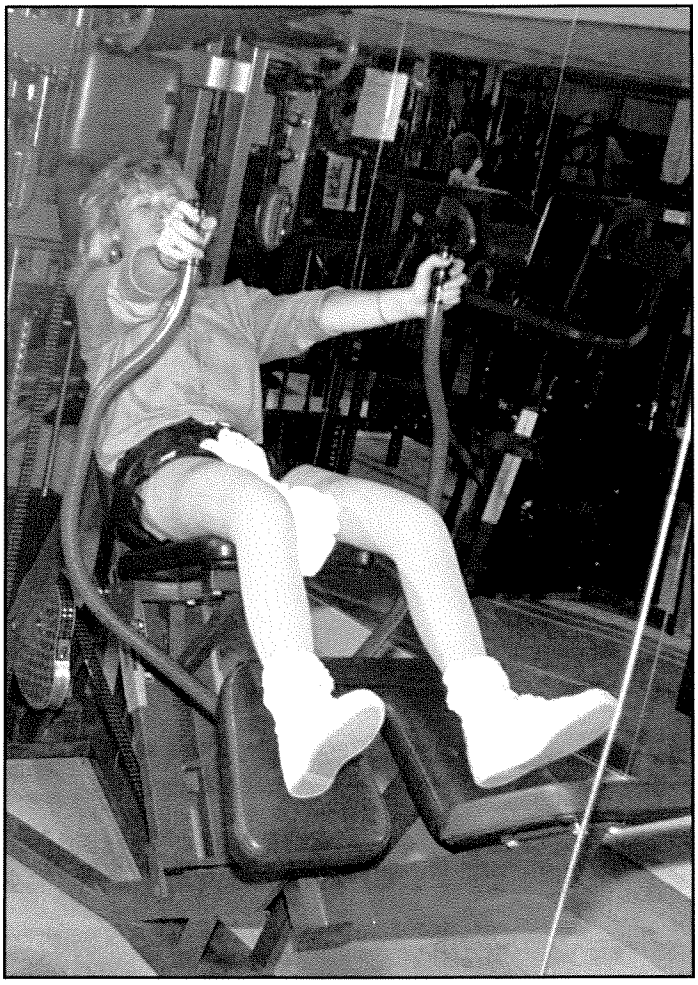
Intermediate.

NOTE

The Nautilus Bench Press is technically referred to as the Nautilus Decline Press. The apparatus is excellent for people with lower limb loss because balance of the weights is not required. It is easy for beginners to use and offers a great range of motion. The back is always supported and a seat belt is available to prevent unwanted movements and to help maintain balance.



Samantha Ellis demonstrates the exercise.



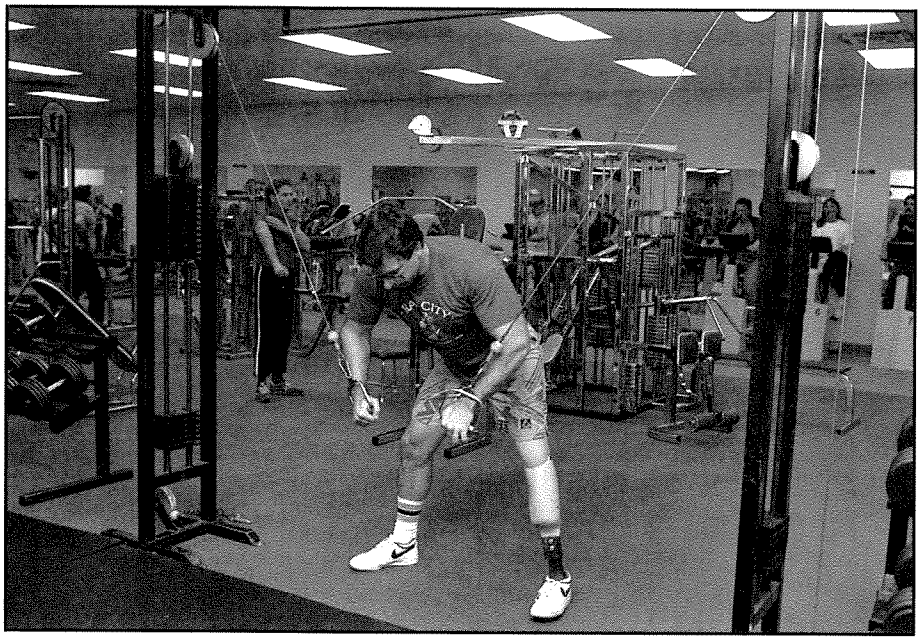
EXERCISE 72. DOUBLE PULLEY CROSS

PURPOSE
Develops the upper pectoral muscles.

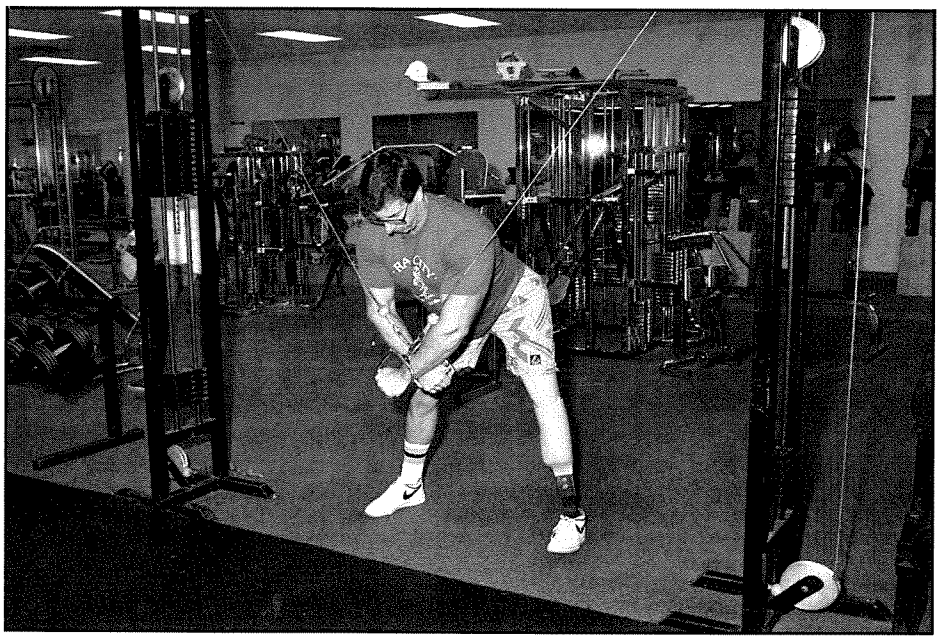
PROCEDURE
- Take hold of the handles attached to the two cables and step forward so that the weights are raised slightly from the weight stack.
- Begin the exercise with the arms outstretched at shoulder level and out to the sides with elbows extended. Flex the arms slightly as you bring them together toward the midline with hands in line with the lower pectorals.
- The hands cross each other past the midline of the body for a full pectoral contraction. Exhale while bringing the arms together and inhale while drawing the arms apart.

MODIFICATIONS
For greater stability, lean forward at the waist and stand with a slight bend of the sound knee, with the feet about 24 inches apart. The prosthetic knee may be positioned slightly behind the sound knee. If standing balance is a problem, Exercises 69 and 70 can be accomplished from a seated position.

SKILL LEVEL
Intermediate.



Mike Nitz demonstrates the exercise.



EXERCISE 73. BENCH PRESS

PURPOSE

Develops the pectoral muscles.

PROCEDURE

- Lie on a bench with your feet flat on the floor and positioned on either side of the bench.
- Take the bar securely in both hands in a grip about shoulder-width apart. (Narrower or wider grips will emphasize different parts of the pectoral muscles: i.e., a close grip with the hands 12-14 inches apart emphasizes the inner pectorals and triceps; a medium grip with hands slightly outside shoulder-width works the outer pectorals; a wide grip as far apart as is comfortable also works the outer pectorals.)
- Inhale as you lower the bar to the chest, but do not rest it on the chest.
- Exhale as you raise the bar from your chest until the elbows are fully extended. Lower the bar slowly to the starting position. Do not arch your back when lifting the weight bar.

MODIFICATIONS

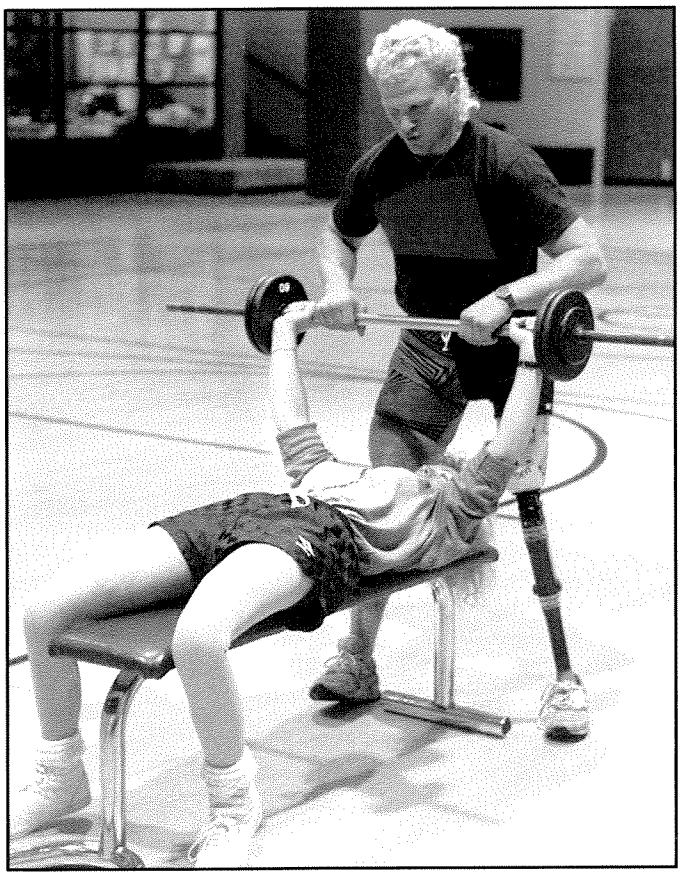
If a spotter is not available, use a Universal or Nautilus bench press. These machines are easier and safer for the beginner. With a spotter, use a bench press with a rack to hold the barbell.

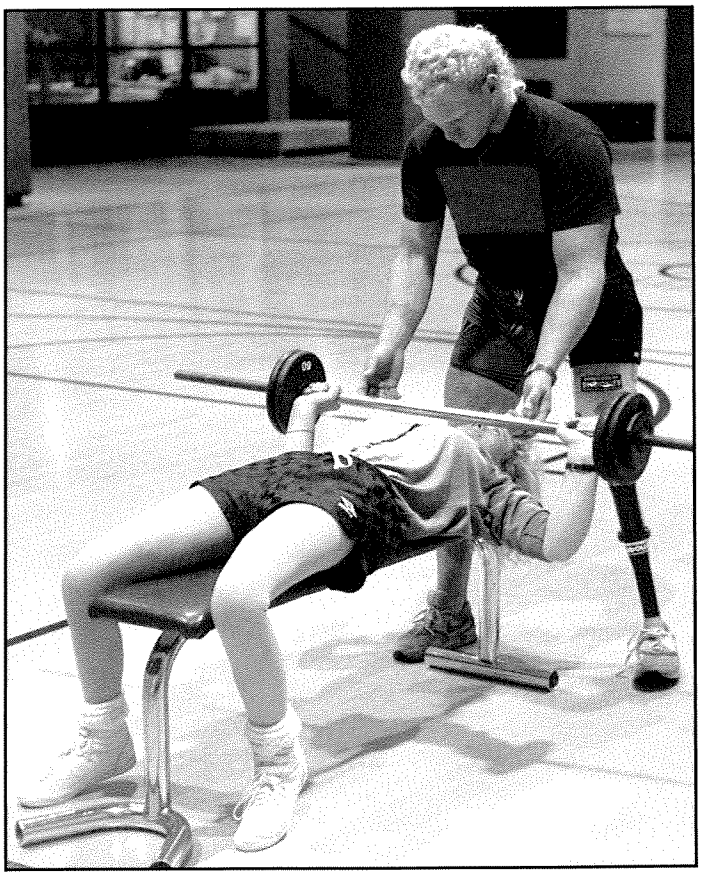
SKILL LEVEL

Advanced.

NOTE

When you are not using a bench with an attached rack to hold the weight bar, a spotter should hand the bar to you and stand by throughout the exercise. This can be done as seen in the photos, but only with light weights to reduce the risk of dropping the weight.





Greg Mannino is spotter for Samantha Ellis as she performs the exercise.

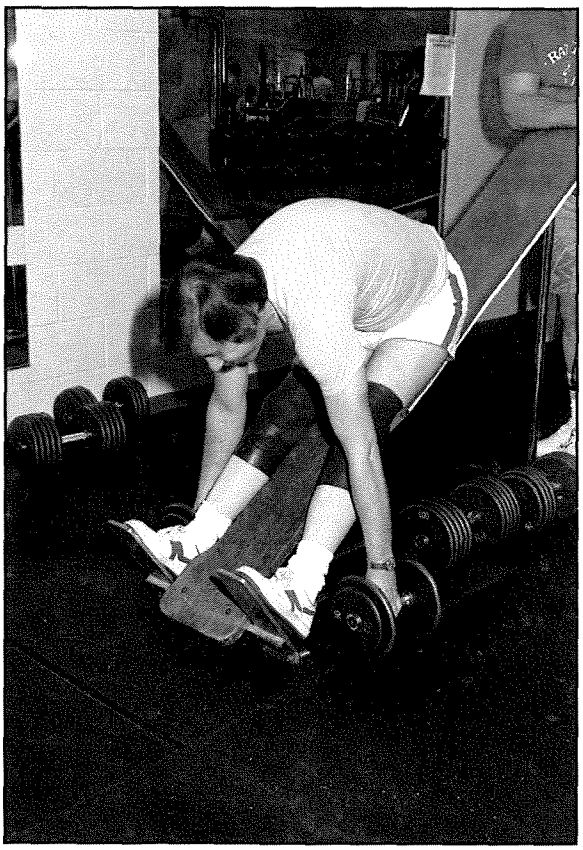
EXERCISE 74. STANDING INCLINE PRESS

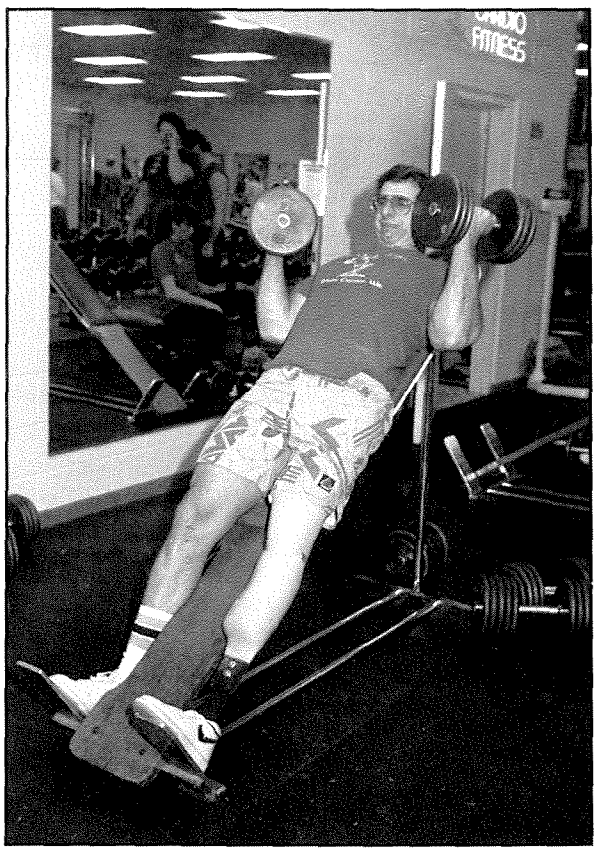
PURPOSE
Develops the pectorals, anterior deltoids, and triceps.

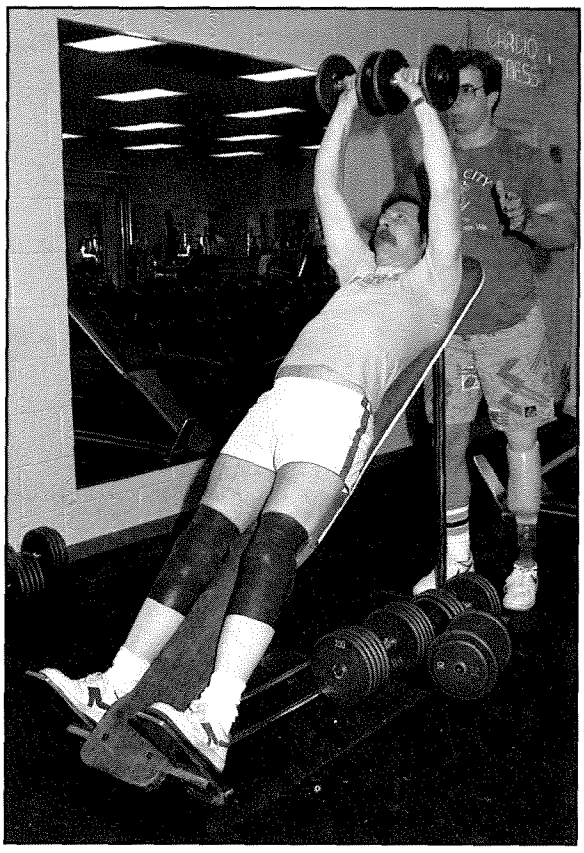
PROCEDURE
- Position yourself on the incline bench and pick up the dumbbells (Step 1).
- In one sweeping motion using the arms, legs, and back, lift the dumbbells up to shoulder level from the floor (Step 2). This is referred to as "cleaning" the weight.
- Press the weight overhead, arms extended (Step 3). Keep the weights close together as demonstrated in the photo.
- Pause momentarily. Lower the weights to shoulder height, keeping your elbows close to your sides (Step 4).
- Exhale when the weights are raised from the shoulders to the top position and inhale when lowering the weight.
- Weights can be raised from the shoulders to the top position.
- Upon completing the desired number of repetitions, lower the weights from the shoulder-height position to below the waist. Keep the arms extended and the back flat against the incline bench.
- Lower the weights by bending at the waist and knees until the weights reach the floor.

SKILL LEVEL
Advanced.

CAUTION
A spotter is recommended when doing this exercise.







John Everett and Mike Nitz demonstrate Step 1, Step 2, and Step 3 of the Standing Incline Press.

EXERCISE 75. DECLINE PRESS

PURPOSE

Develops the pectoral muscles and triceps. The decline bench is one of the few ways to effectively work the bottom portion of the pectorals.

PROCEDURE

- Sit on the raised end of the decline bench and position your feet under the bench footpads.
- Slowly lower yourself back until you are flat on the bench (the spotter can assist you in doing this). Before going further, make sure your prosthesis is not slipping. If it is, readjust so you are secure and balanced.
- Have your spotter hand you the bar. Grasp it so that your hands are slightly wider than shoulder-width apart.
- Inhale as you slowly lower the bar to between the mid-chest and neck. Do not allow the bar to touch the chest. Pause momentarily at this position.
- Exhale as you push the weight back to the starting position. Do not grip the bar too tightly as it will tire you and detract from the strengthening effect on the pectoral muscles.
- Do not raise your head from the bench while pressing the weight.

MODIFICATIONS

— Auxiliary suspension may be necessary for some individuals to prevent the prosthesis from slipping or coming off. Good balance and agility are required to climb on and off the apparatus. If this is a problem, you may want to adjust the angle of the seat to less of a decline, which will make it easier to get on and off the bench. However, not all benches can be adjusted.

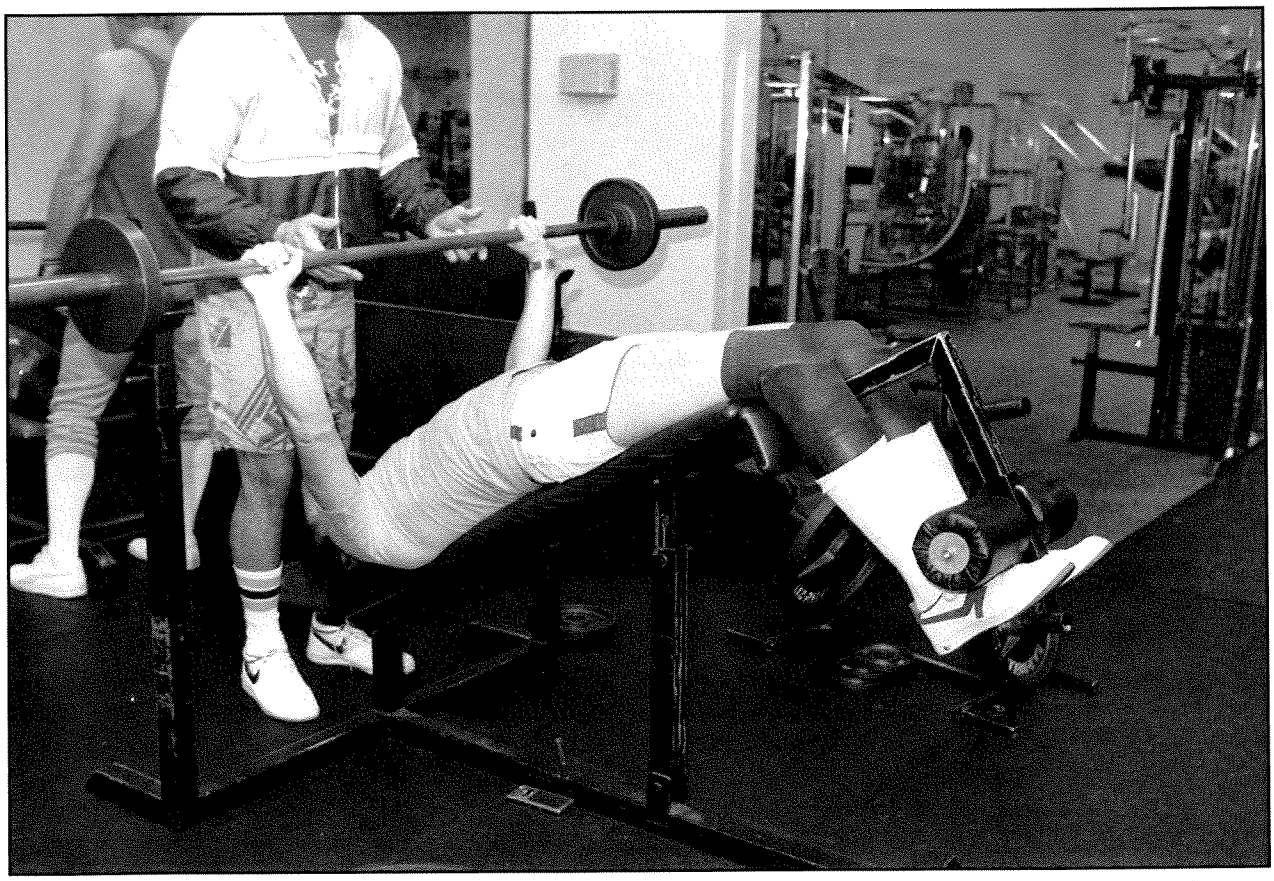
— Those who do this exercise without wearing a prosthesis may find the upper body improperly aligned, since the lower body may not be balanced symmetrically because only one leg is used for support. The person with BK amputation who is not wearing a prosthesis may flex the residual limb over the edge of the bench to give additional support. Those with AK amputation or hip disarticulation should try to keep the pelvis straight by lowering the decline of the bench. This may be necessary to maintain good body alignment.

SKILL LEVEL

Advanced.

CAUTION

This exercise can be stressful to the lower back. Omit if low back problems are present.



John Everett is wearing the ActivSleeve Suspension System to keep his legs intact while doing this exercise.

NOTE

This exercise should always be done with a spotter present. A spotter is absolutely necessary if the exercise is done with the prosthesis removed. If a spotter is not available, use the Nautilus Bench Press (also known as the Nautilus Decline Press).

EXERCISE 76. PARALLEL BAR DIPS

PURPOSE

Develops the pectorals, serratus anterior, and triceps.

PROCEDURE

- Stand on the platform and take hold of the bars on either side. Do not grip the bar too tightly.
- Raise your body by extending both arms, pushing yourself up by your chest muscles and triceps, as shown in the top photo. Bend your knees so that your feet do not touch the platform. (On the Nautilus Multipurpose Station you can also raise the height of the dipping bars to prevent the feet from touching.)
- Lower your body weight by bending the arms while keeping your elbows close to your sides. Lower yourself at least until your elbows are the same height as your shoulders. The forearms and biceps should touch each other. (If you are able to drop yourself lower, i.e., shoulders below the elbows, you will get a better stretch and work the muscles of the pectorals and triceps through a wider range of motion.)
- After reaching the bottom position, pause briefly, then push yourself back up to the starting position (arms fully extended) before repeating the exercise.
- Inhale as you lower your body and exhale as you extend your arms to reach the starting position.

MODIFICATIONS

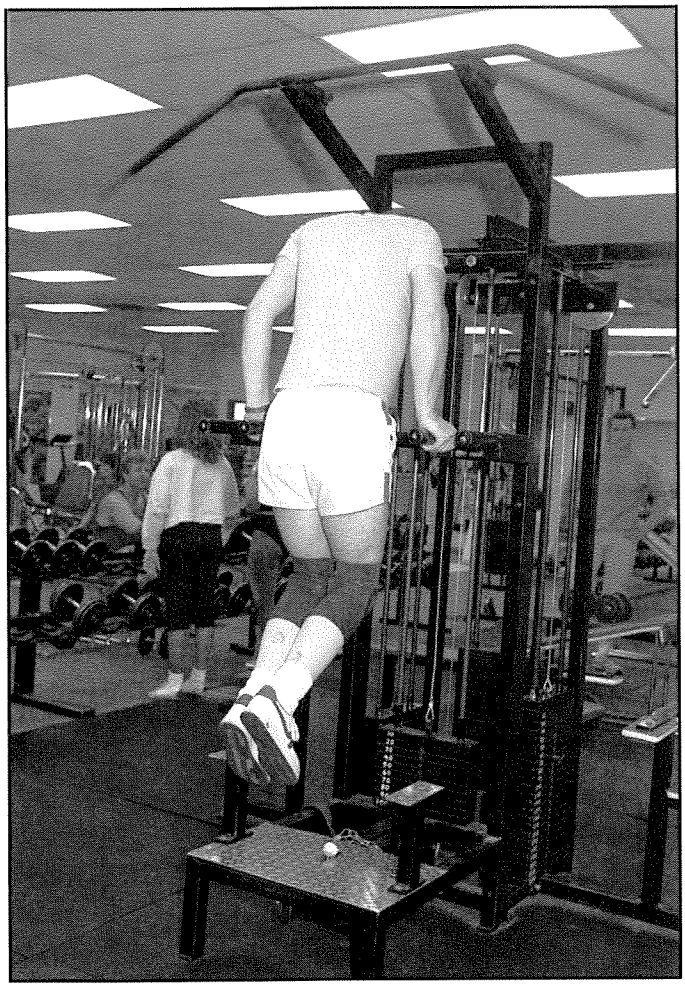
If flexing at the knees to prevent the feet from touching the platform is difficult, you can place the sound leg under the prosthesis for support, as seen in the bottom photo. Some Nautilus machines are height-adjustable and can be adjusted so your feet do not touch the floor.

SKILL LEVEL

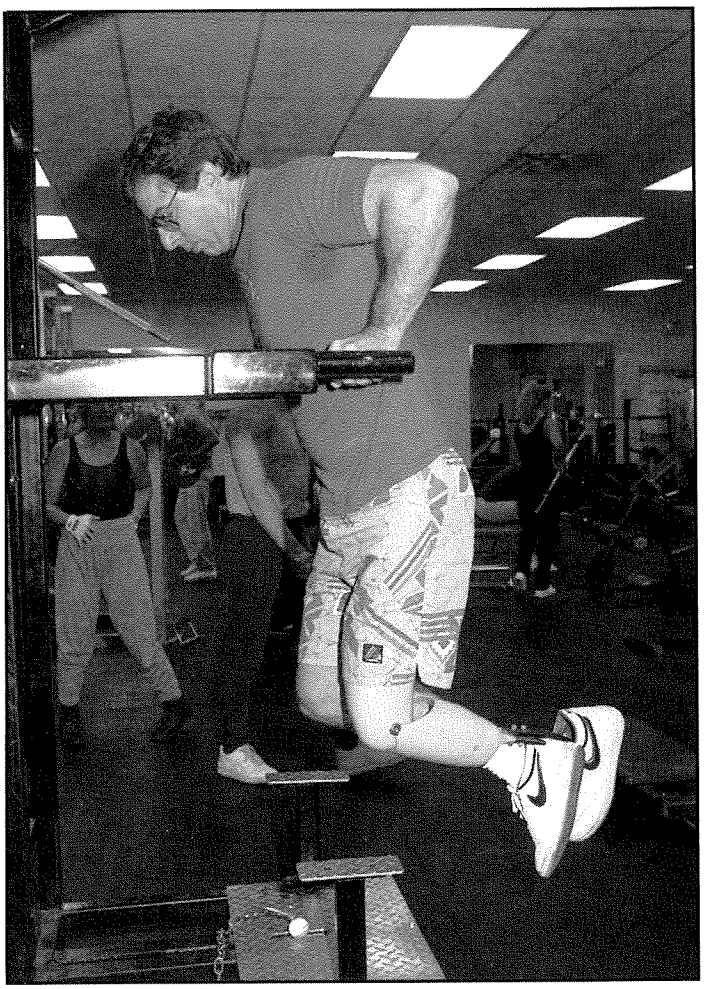
Advanced.

NOTE

Do not rest at the top position; lower yourself slowly, making sure that your body movements are kept to a minimum. Do not allow your body to swing back and forth.



John Everett flexes the knees to keep them from touching the platform.



Mike Nitz performs a dip with crossed legs in order to keep the feet from touching the platform.

CAUTION

There is a potential risk of injury in any form of exercise, whether or not there has been previous back injury. As noted in the previous chapters, special care should be taken when doing certain exercises, such as sit-ups and other abdominal exercises involving hyperextension of the back. Squats and dead lift leg exercises require special caution, as noted.

If you have had a previous back injury, or acute or chronic back problems, check with your physician before attempting the exercises in this chapter. You may need to avoid lifting heavy weights in your exercise program. To compensate, you can do more repetitions with light weights in order to increase resistance. If you are able to increase the weights you lift, do it gradually and only when you are familiar enough with the exercise to know how to do it correctly and when to stop. This is particularly important if you experience pain or discomfort.

Use caution when doing exercises that make the lower back more vulnerable to injury. Follow the directions closely and do not increase the weights you lift rapidly. Always have someone "spot" you while exercising the back, particularly when you are lifting weights. A weight belt should always be used.

Exercises that make the lower back vulnerable to injury are noted in this chapter (i.e., Exercises 86, 87, 88, and 89); they are not recommended for persons with previous back injury, who are not experienced with the equipment, or who are not in condition.

12

BACK

Strong and flexible back muscles are essential for maintaining good posture and an adequate range of motion, and can reduce the risk of injuries that may occur from everyday activities. Certain exercises are also beneficial in easing the backaches and pain that are often associated with a chronic "bad back." Many people with AK and BK amputation experience back pain. Although no proven scientific data can pinpoint the exact cause, it is believed that a discrepancy in leg length, poor gait habits, and improper alignment are contributing factors.

In a 1985 study at the Bioengineering Centre at the University College London, 80 percent of a study group of people with AK amputation reported that they had back pain. The group recorded a statistically greater level of leg length difference and scoliosis compared with a nonamputation control group. The results of the study suggest that there may be some relationship between the leg length difference recorded in the group with amputations and the degree of incapacity due to lower back pain.[1]

An earlier study conducted by the Veterans Administration included several categories affecting the veteran with a lower limb amputation. One category that was surveyed among a cross-section of veterans with amputations, both traumatic and dysvascular, was back pain. Fifty-four percent of the 81 veterans with amputation surveyed in this category complained of back pain.[2]

Exercises for the back usually concentrate on specific muscles in either the upper or lower back. Although the major muscles are located in the same region of the body, they are exercised with distinctly different body movements to isolate either the upper or lower back.

The major muscle groups of the upper back are teres major and minor, trapezius, and latissimus dorsi. The muscles emphasized in the exercises that follow are the trapezius muscles (commonly referred to as "traps") and the latissimus dorsi muscles (commonly referred to as "lats"). The main lower back muscle emphasized in the exercises is the erector spinae (sacrospinalis), a large and deep three-part muscle.

The correct techniques for lifting weights, or for lifting any heavy or bulky items encountered in a normal work day, are essential in protecting the back from injury. Some general rules are:

1. Whenever picking up a weight, the back should be straight and the head up. Bend by flexing the knees before beginning to lift. This permits you to lift the weight primarily with the legs and not the back.
2. Hold the weight or object close to your body for added support and balance. In this way, there is less risk of injury through losing your balance or dropping the object.
3. Get help or use a dolly to lift or move heavy objects.

[1]A. Middleditch and P. Jarman, *Assessment of the Spine in Above-Knee Amputees, Bioengineering Centre Report.* London: University College London, 1985, pp. 123-128.

[2]F.T. Hoaglund, *et al.,* "Elevation of Problems and Needs of Veteran Lower-Limb Amputees in the San Francisco Bay Area During the Period 1977-1980." *Journal of Rehabilitation Research and Development,* Vol. 20, No. 1, 1983, pp. 57-71.

UPPER-BACK EXERCISE ROUTINE

Muscle	Exercise	Title
Latissimus Dorsi	77	Bent-over Rowing
Latissimus Dorsi/Elbow Flexors	78	Seated Rowing
Latissimus Dorsi	79	Nautilus Lat Pull-down
Latissimus Dorsi	80	Wide-grip Lat Pull-down
Latissimus Dorsi	81	Wide-grip Front Chin-up
Latissimus Dorsi/Elbow Flexors	82	Reverse Close-grip Front Chin-up
Latissimus Dorsi/Biceps	83	Reverse Medium-grip Front Chin-up
Trapezius	84	Seated Shoulder Shrug
Trapezius	85	Standing Shoulder Shrug

LOWER-BACK EXERCISE ROUTINE

Muscle	Exercise	Title
Erector Spinae	86	Hyperextension
Abdominals/Hip Flexors	87	Reversed Hyperextension (Intermediate)
Erector Spinae/Abdominals	88	Reversed Hyperextension (Advanced)
Erector Spinae	89	Stiff-legged Barbell Dead Lift

INCREASING THE NUMBER OF REPETITIONS

Always do warm-up exercises before lifting weights.

Start with a minimum of 8 repetitions with a given weight. If a minimum of 8 repetitions cannot be completed, the weight is too heavy for you and the resistance should be lowered until 8 repetitions can be completed.

When 12 repetitions can be successfully completed, the weight should be increased by 5-10 pounds. When 12 repetitions can be completed with the increase in pounds, the weight may be increased again.

Work up to 15-20 repetitions per set for muscle maintenance, endurance, and tone.

When performing exercises with free weights, it is recommended that 2-6 sets for each particular muscle group be used.

CAUTION

Beginners are encouraged to use free weights with a spotter present. Certain exercises will require a spotter regardless of skill level (e.g., squats).

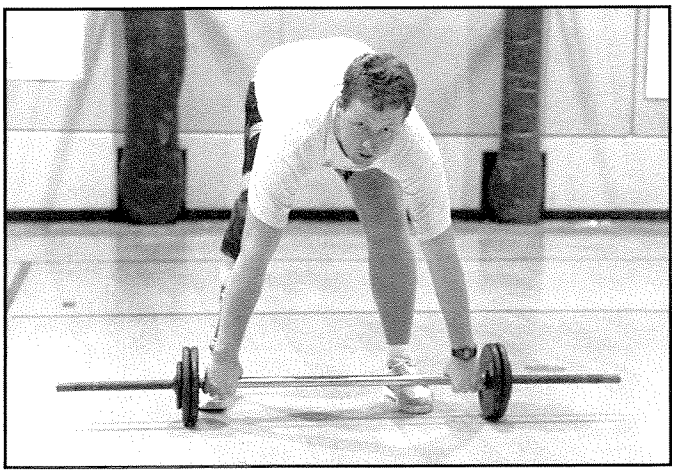
EXERCISE 77. BENT-OVER ROWING

PURPOSE
Develops the latissimus dorsi muscles.

PROCEDURE
- Roll the bar close to your toes.
- Keep your feet about shoulder-width apart.
- Bend over and take hold of the bar. It is best for beginners to use the grip width that is most comfortable and then vary it with practice.
- Keep your back straight and approximately parallel with the floor. With your knees bent slightly, inhale and lift the bar until it nearly touches the lower portion of your chest. This exercises all portions of the lat muscle.
- Keep your head up throughout and do not flex your wrists as you pull up the bar. Exhale as you lower the bar. Do not let the bar touch the floor during the repetitions of the exercise.

MODIFICATION
If balance is a problem, try Seated Rowing (Exercise 78).

SKILL LEVEL
Intermediate.



Richard Hughes wears an Endolite Multiflex Ankle, which allows the prosthetic foot to remain flat on the floor for better stability.

EXERCISE 78. SEATED ROWING (SEATED TWO-ARM LAT PULL-IN)

PURPOSE

Primarily strengthens latissimus dorsi and, to a lesser degree, the elbow flexor muscles.

PROCEDURE

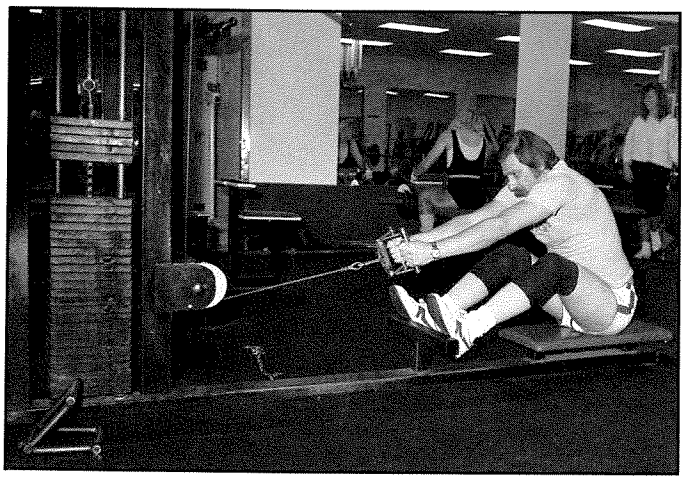
- Sit on the platform seat in front of the pulley.
- Bend your knees slightly, keeping your feet firmly against the foot plate.
- Grasp the pulley handles with both hands and remain in a bent-forward position.
- With arms outstretched, knees bent, and upper trunk bent forward, pull the cables in toward the chest just below the pectorals. Inhale as you pull. To keep strict form, keep torso erect or lean slightly forward. Lean back only on your last repetitions and only if you would not otherwise be able to complete them.
- Exhale as you slowly lower the weights back to the starting position.
- Minimize back movements.

VARIATION

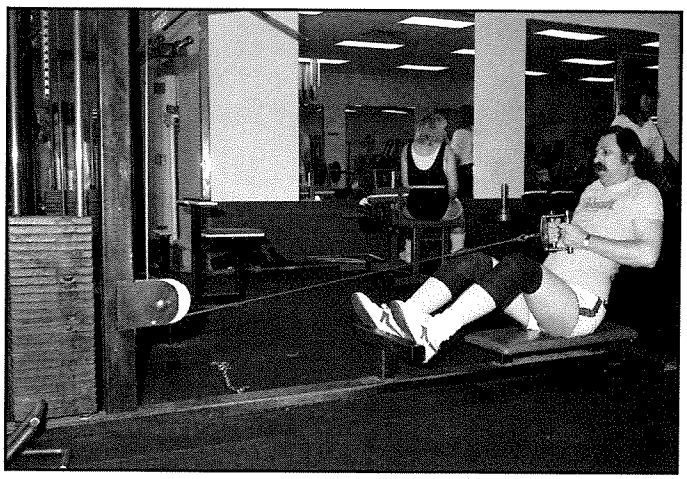
For greater muscle stretch, lean forward. This variation will also use the lower back muscles for stabilization when bringing the torso to an upright position.

SKILL LEVEL

Intermediate.



John Everett completes the final repetitions of a demanding set.

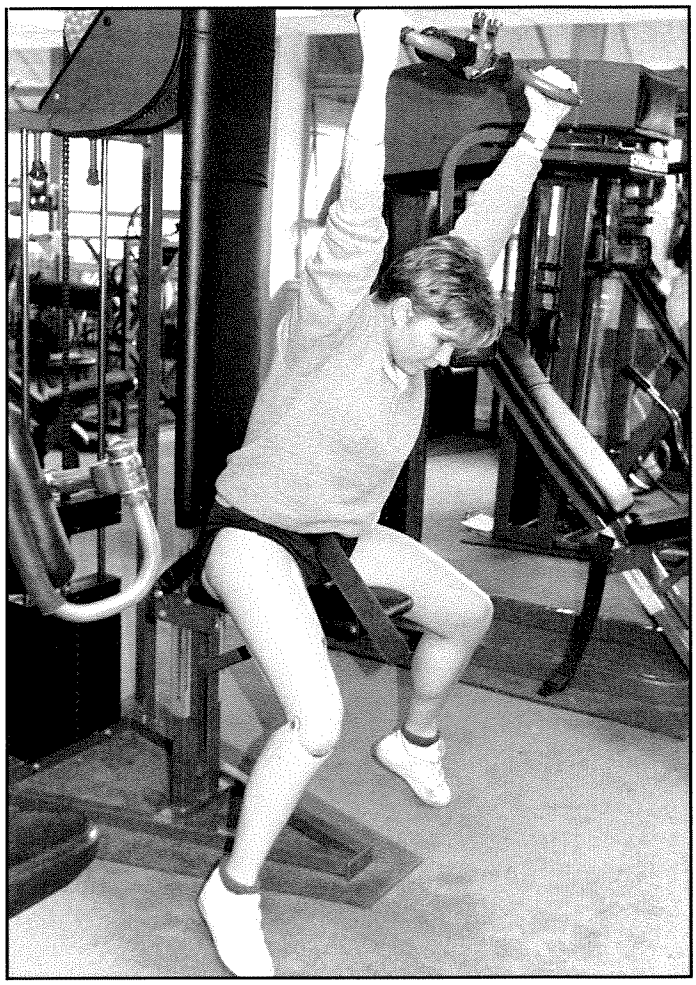


EXERCISE 79. NAUTILUS LAT PULL-DOWN

PURPOSE
Develops the latissimus dorsi muscles.

PROCEDURE
- Adjust the height of the seat so that the weights are slightly raised off the rack when your arms are fully extended overhead.
- Secure yourself with the seat belt. Lean forward and keep your feet on the ground for support.
- Take hold of the bar with both hands in a firm grip. Begin by pulling the bar down until it touches the back of your neck at a level slightly above the shoulders.
- Inhale while pulling the bar down to a count of two.
- Exhale as you slowly let the bar back up to a count of four.

SKILL LEVEL
Intermediate.



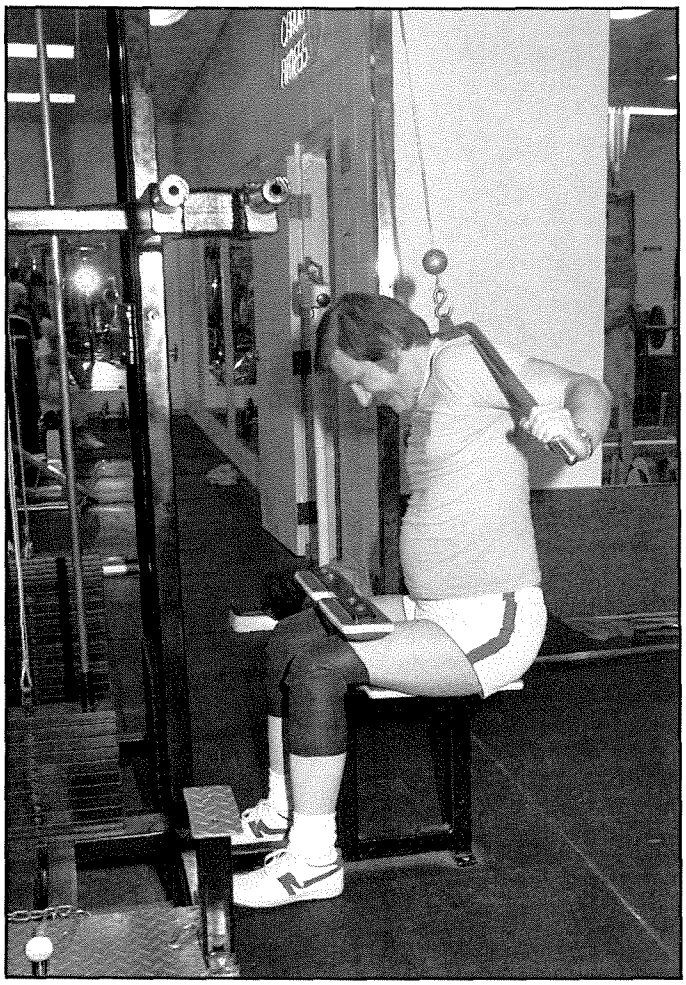
Linda Pedersen uses her feet for support as she begins to pull the bar down.

EXERCISE 80. WIDE-GRIP LAT PULL-DOWN

PURPOSE
Develops the latissimus dorsi muscles.

PROCEDURE
- Adjust the seat so that when your arms are fully extended above your head the weights are slightly raised off the rack. (The adjustable padded section positioned across the front of your thighs helps to hold you down when lifting heavy weights. In addition, a spotter can exert downward force on your shoulders to keep you from coming up off the seat.)
- Grasp the bar as near to its end as is comfortable.
- Pull the bar down behind your neck to a level just above your shoulders with a count of two.
- Inhale while pulling the bar down and exhale while letting the bar back up to the starting position with a count of four.

SKILL LEVEL
Intermediate.



NOTE

This is essentially the same as Exercise 79 but on a different apparatus.

Note the use of the padded section to help hold the legs down.

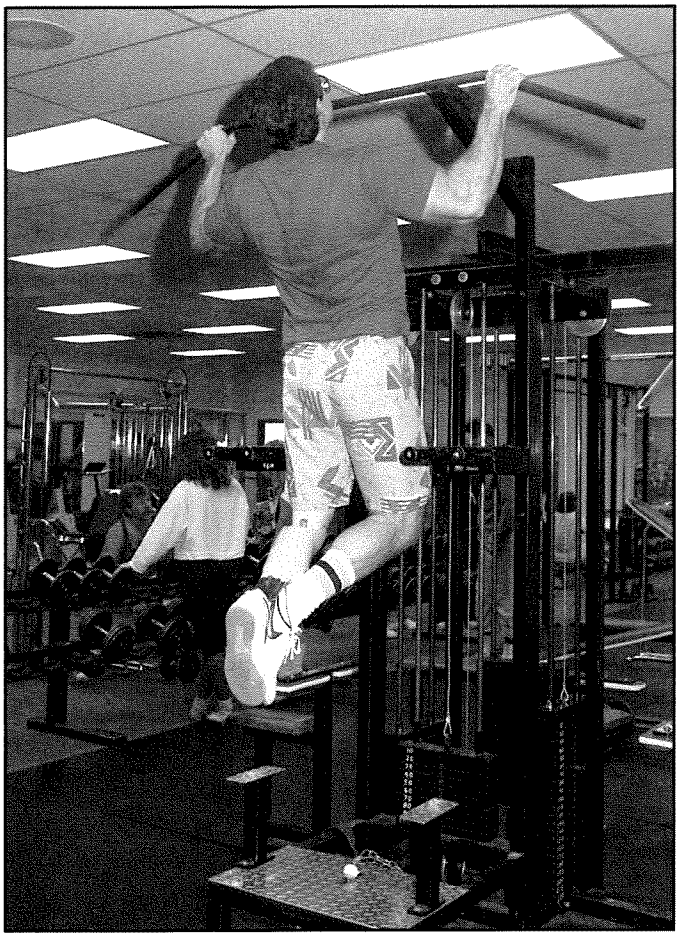
EXERCISE 81. WIDE-GRIP FRONT CHIN-UP

PURPOSE
Develops the latissimus dorsi muscles.

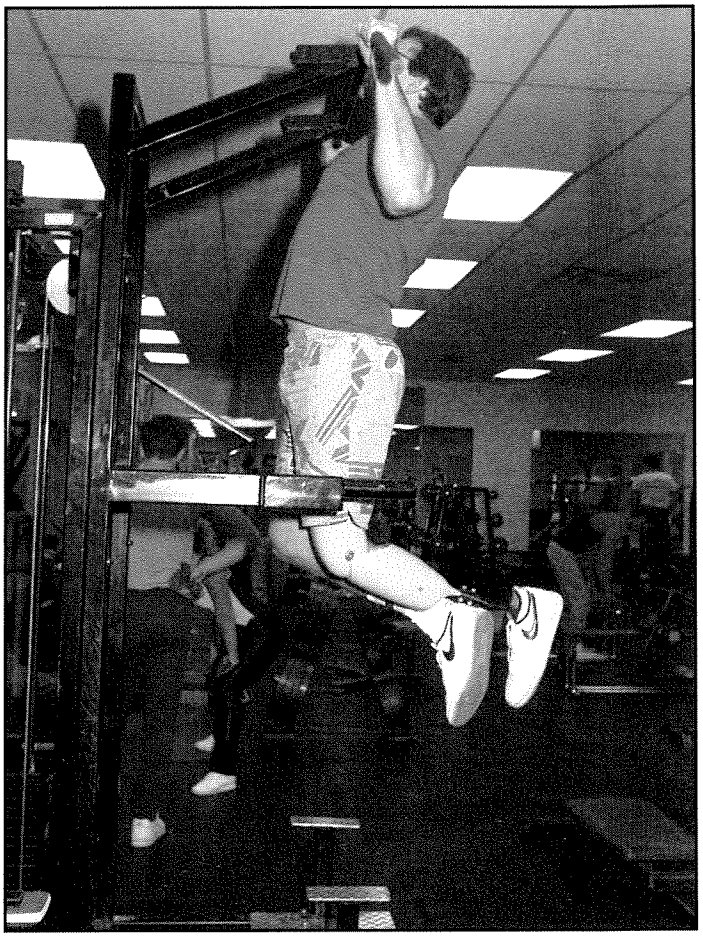
PROCEDURE
- The overhead bar should be at least 6 inches higher than you can reach from a standing position with your arms fully extended. Stand on a stool to reach the bar and take hold of it with your palms facing away from you. Use a wide grip outside the width of the shoulders.
- Hang with your arms extended at full length. Flex at the knees if necessary to keep your feet off the platform.
- Inhale as you pull yourself up to the bar, attempting to touch it with your chin. It is acceptable to have the back slightly hyperextended, but try to keep your body from swinging back and forth.
- Exhale as you lower yourself back down until your arms are fully extended.

SKILL LEVEL
Advanced.

NOTE
If this exercise is too difficult, the Reverse Close-Grip Front Chin-Up (Exercise 82) may be substituted.



The AK prosthesis can be supported by the sound leg in a flexed position, as shown by Mike Nitz.



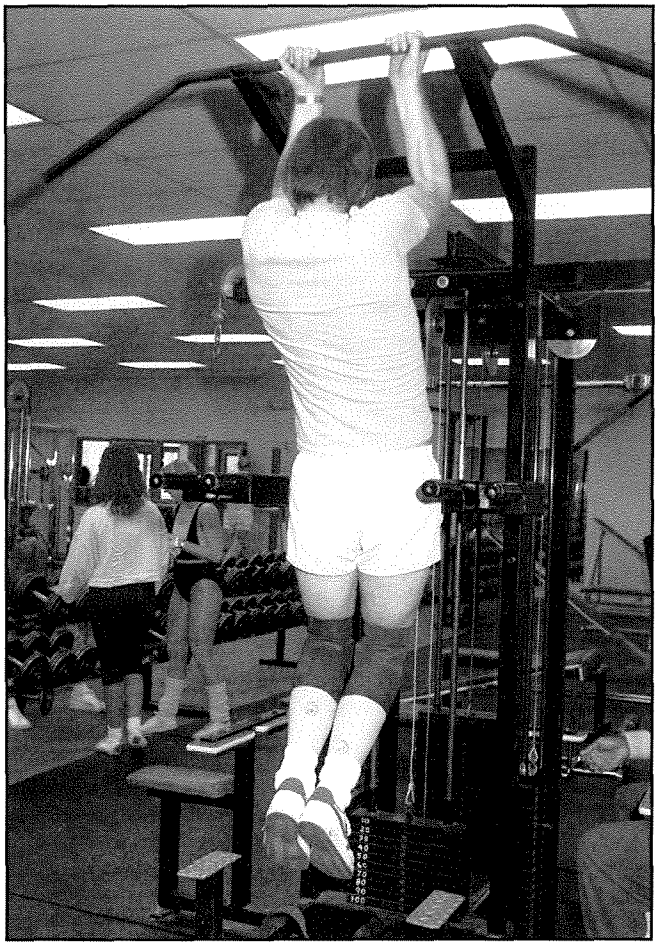
EXERCISE 82. REVERSE CLOSE-GRIP FRONT CHIN-UP

PURPOSE
Develops and strengthens the latissimus dorsi and, to a lesser degree, the elbow flexors.

PROCEDURE
- The overhead bar should be at least 6 inches higher than you can reach from a standing position with your arms fully extended. If this is not possible, keep your knees flexed while lifting your body to prevent your feet from touching the platform.
- Grasp the bar with your hands about 6 to 8 inches apart and palms facing you.
- Inhale as you pull yourself up, attempting to touch your chin to the bar. Do not swing or sway your body.
- Exhale as you lower yourself to the hanging position.

MODIFICATION
Use a step stool to reach the bar.

SKILL LEVEL
Advanced.



John Everett's knees are flexed to keep his feet from touching the platform.

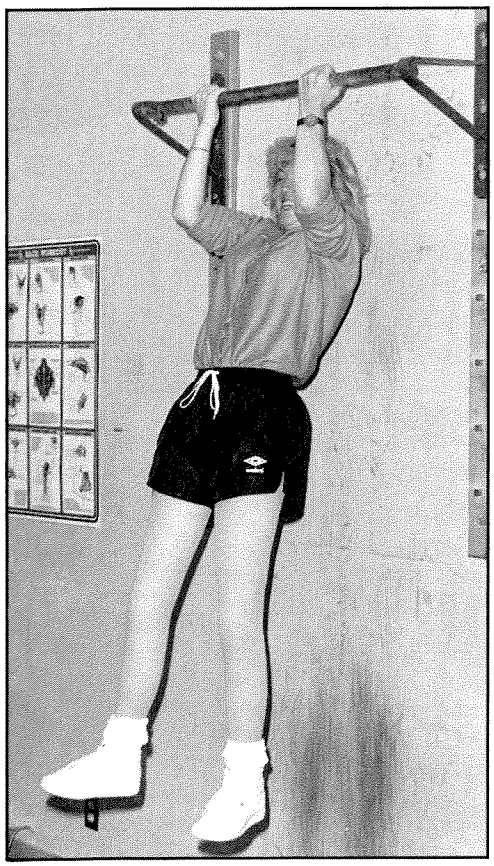
EXERCISE 83. REVERSE MEDIUM-GRIP FRONT CHIN-UP

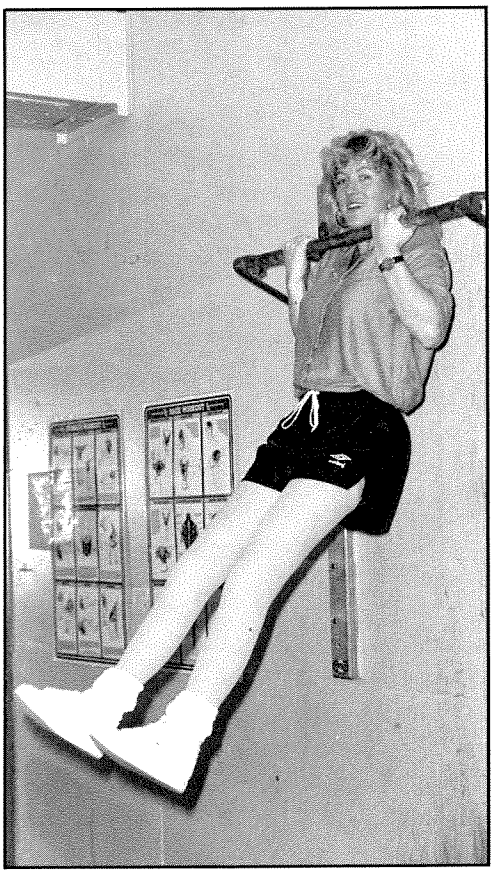
PURPOSE
Develops the latissimus dorsi muscles and, to a lesser degree, the biceps.

PROCEDURE
- Adjust the bar so that you must stretch to reach it. Your feet should not touch the floor when you hang with your arms fully extended.
- Grasp the bar; grip with palms facing you. (Your hands should be about 10-12 inches apart, not wider than your shoulders.) Raise up at least until your chin touches the bar.
- Flexing at the hips helps to maintain the body position.
- Pause momentarily in the top position and then lower yourself slowly to the floor. Inhale as you pull yourself up and exhale as you return to the starting position.

MODIFICATION
In order to reach the bar, some individuals may need to use a step stool or have a spotter help them.

SKILL LEVEL
Advanced.





Samantha Ellis flexes slightly at the hips as she rests momentarily at the top position.

EXERCISE 84. SEATED SHOULDER SHRUG

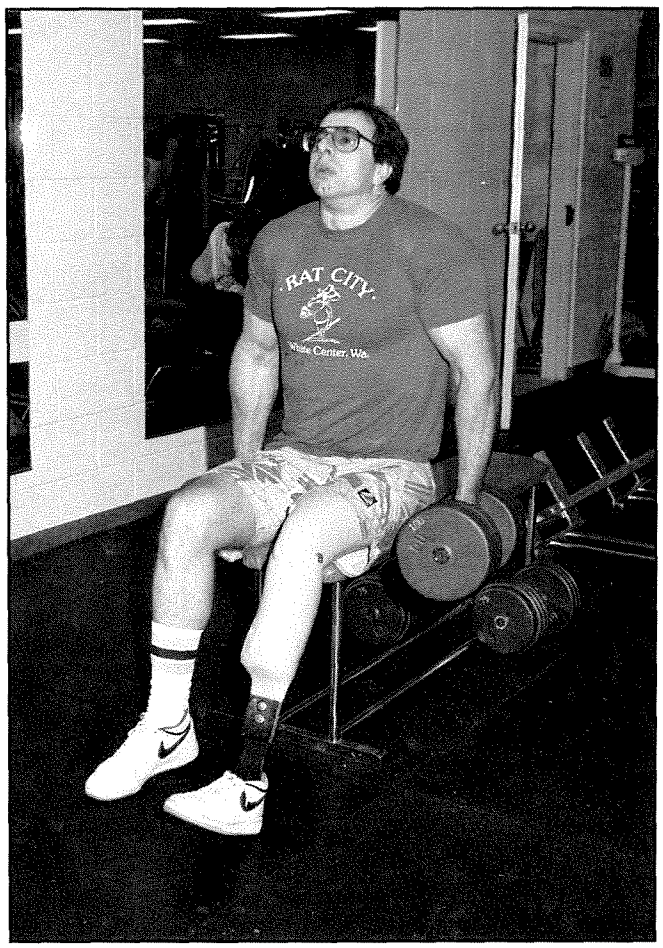
PURPOSE
Develops the trapezius muscles.

PROCEDURE
- Grasp the dumbbells in each hand with your palms facing your body, and take a seated position at the end of the bench.
- Keep your back straight, head up, feet approximately 8-10 inches apart, with your arms hanging at your sides. As you begin each repetition, allow your shoulders to drop as low as possible with the weight of the dumbbells.
- Inhale and raise your shoulders as high as you can; bring your shoulders up to your ears. Keep your arms fully extended and down at your sides.
- Exhale as you lower your shoulders and arms to the starting position.

VARIATION
Roll the shoulders in a circular motion front to back and then back to front.

MODIFICATION
Keep the prosthesis slightly forward with pressure on the heel to help you push against the floor and stabilize your balance when lifting weights from the seated position.

SKILL LEVEL
Intermediate.



Mike Nitz demonstrates a Seated Shoulder Shrug position with 100-pound dumbbells.

EXERCISE 85. STANDING SHOULDER SHRUG

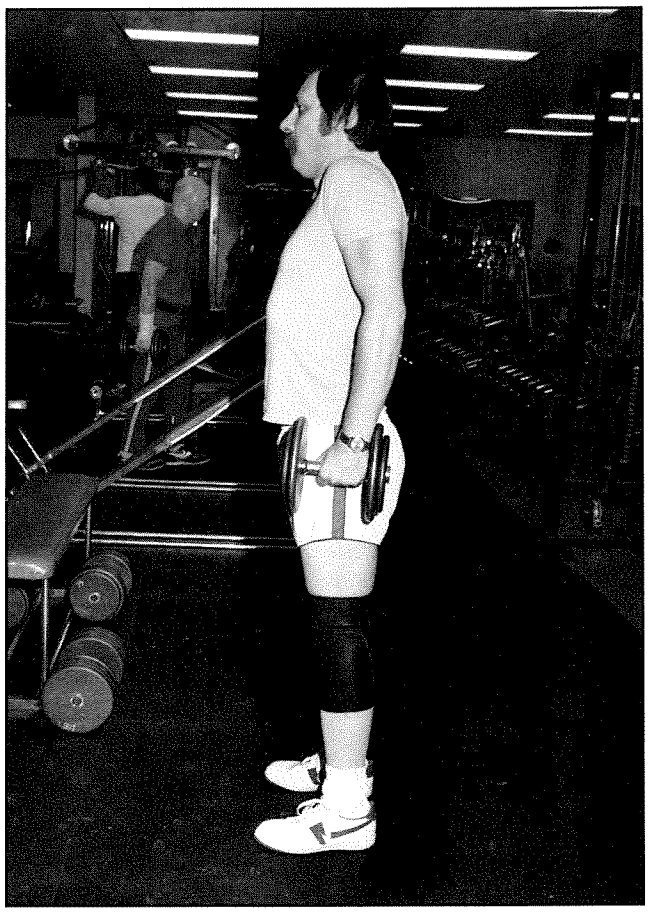
PURPOSE
Develops the trapezius muscles.

PROCEDURE
- Bend your knees and pick up the dumbbells from the floor, using your legs to lift the weight.
- Stand erect and hold the dumbbells by your sides with arms extended at full length, back straight, and feet about shoulder-width apart.
- Allow your shoulders to drop as low as possible with the weight of the dumbbells.
- Inhale as you raise your shoulders in an attempt to touch your ears. Do not bend the elbows.
- Exhale as you lower your shoulders to the starting position.
- When the desired number of exercise sets is completed, keep your head up, your back straight, and bend at the knees as you lower the weights to the floor.

VARIATION
Roll the shoulders in a circular motion front to back and then back to front.

MODIFICATION
If standing balance is a problem, choose the Seated Shoulder Shrug (Exercise 84).

SKILL LEVEL
Intermediate.



John Everett demonstrates the exercise.

EXERCISE 86. HYPEREXTENSION

PURPOSE

Develops lower back strength.

PROCEDURE

- Climb onto the hyperextension bench in a face-down position, with your lower abdomen and hips resting on the support above the hand bars. Grasp the hand bars for balance while getting into position.
- Your legs should be outstretched between the two leg support bars. To help maintain body position, the legs are held down by the upper padded bar.
- Lower your torso, let go of the hand bars, and fold your arms across your chest, as demonstrated by Linda Pedersen in the photo.
- Raise your trunk up until your body is about parallel with the floor. The arms may be folded across the chest, outstretched toward the feet, or out to the side.
- Arch your back and raise your body beyond the parallel position; then lower yourself down slowly as in the photo and repeat the sequence.
- As you advance in your physical conditioning, you may raise your back slightly beyond the parallel position, as shown in the photo.
- Inhale while raising your body and exhale while lowering it.

VARIATIONS

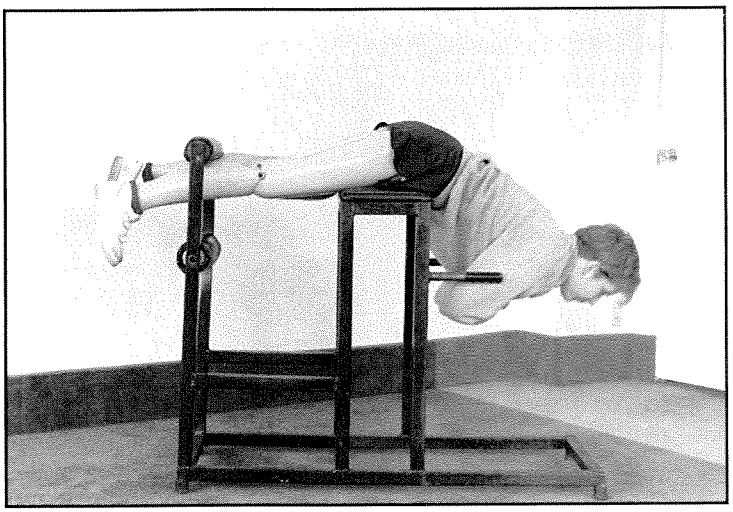
For an enhanced workout, perform one or more of the following steps: 1) hold the body in the up position for a few seconds, then lower yourself down slowly; 2) hold a weight behind the head or against the chest (whichever is more comfortable); 3) twist to each side (left, center, then right), alternating on each repetition; 4) hold the hands behind the head during the entire exercise. The hands may be held against the chest when starting and out to the sides as the exercise is completed (this may be easier for the beginner). The important thing is not to let the arms swing back and forth during the exercise.

SKILL LEVEL

Intermediate.

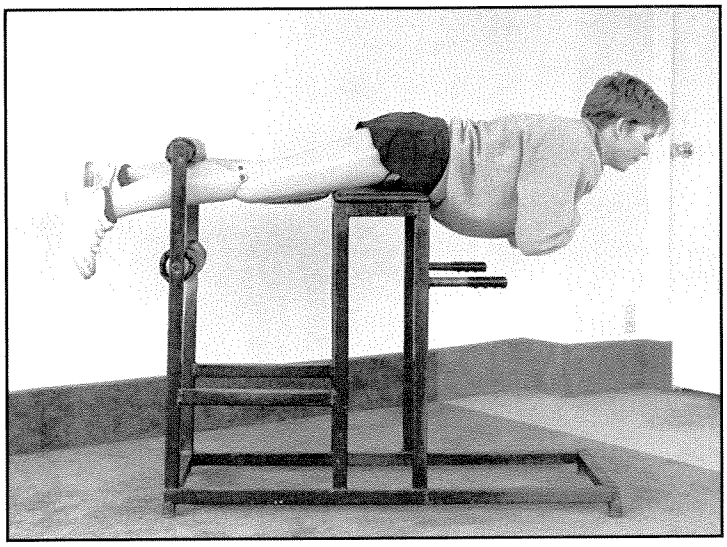
NOTE

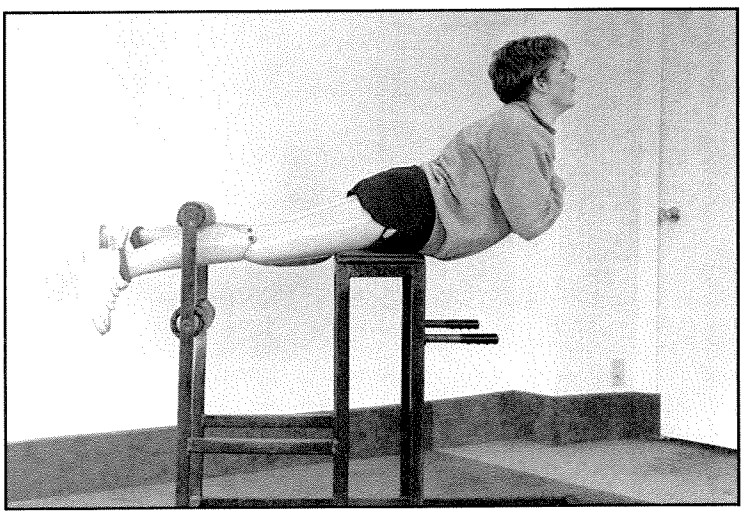
Beginners should be instructed on how to get into the proper position on the hyperextension bench without the danger of falling or straining. Start with the position demonstrated and work up to the position shown as the back muscles are strengthened. Assistance may be needed in positioning an AK or BK prosthesis between the support bars. To rest between sets, turn over and sit up on the bench, support your weight with your arms, or step completely out of the apparatus.



CAUTION

This exercise should be performed at each individual's tolerance level, starting with a limited range of motion. This exercise is not recommended for people with previous back injury.





Linda Pedersen demonstrates the Hyperextension Exercise.

EXERCISE 87. REVERSED HYPEREXTENSION (INTERMEDIATE)

PURPOSE
Strengthens and stretches the abdominal muscles and hip flexors.

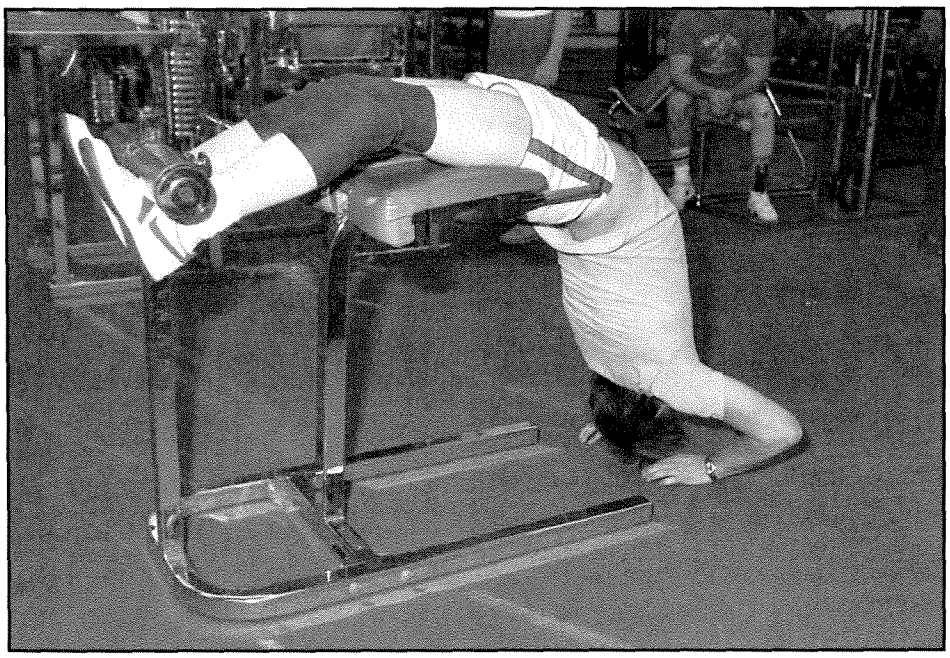
PROCEDURE
- Sit on top of the hyperextension bench and place your feet underneath the leg supports.
- Balance yourself by holding the side bars. Make sure your feet are securely positioned under the support bar.
- Slowly lower yourself backward and down until your hands reach the floor.
- Hold this position to stretch the abdominals. Bring yourself back to an upright position by doing a sit-up or by having a spotter help you.

MODIFICATION
Use auxiliary suspension such as a cuff strap with a waistbelt or a latex suspension sleeve to hold the prosthetic leg on.

SKILL LEVEL
Intermediate.

CAUTION

This exercise is not recommended for people with previous back injury. Beginners should have an assistant to help them lower and raise the torso until they can do it by themselves without risk.



John Everett demonstrates the reverse of the position shown in Exercise 86. He can stretch the low back and also perform sit-ups from this position. (You may not want to drop down this far in order to do sit-ups.)

EXERCISE 88. REVERSED HYPEREXTENSION (ADVANCED)

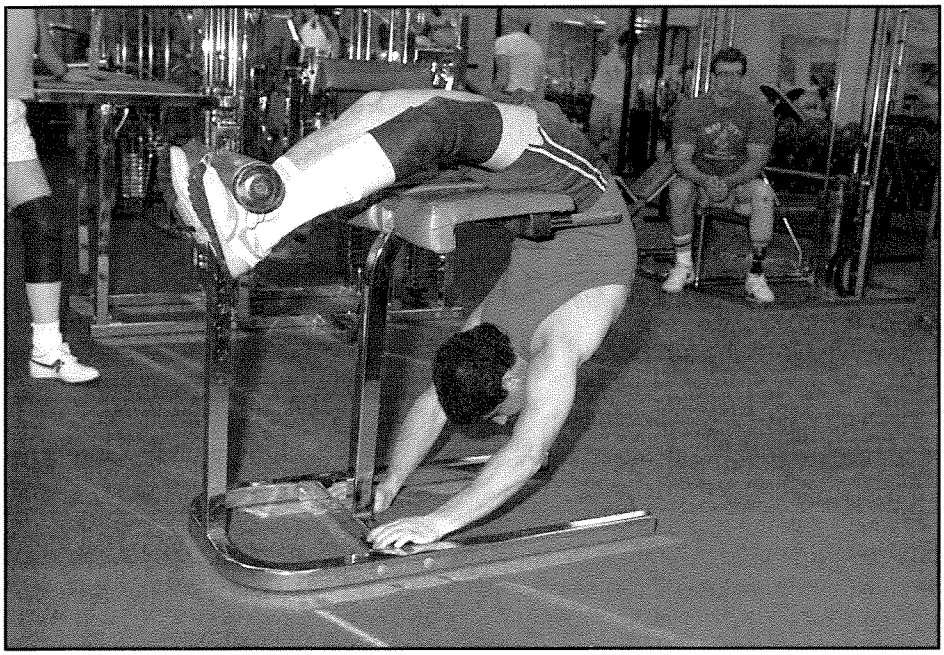
PURPOSE
Strengthens and stretches the lower back and, to a lesser degree, the abdominal muscles. **Attempt only after noting carefully the caution statement below.**

PROCEDURE
- Perform the first three steps from Exercise 87 (Intermediate Reversed Hyperextension). When your hands reach the floor, walk your fingers across the floor until you reach the center post (or as close as possible).
- For each 6-12 inches of finger-walking, hold the position 10-20 seconds. This slow development of the stretch will allow you to progress in a safe manner.
- Make sure to keep your head back. Make sure you have positioned yourself so that the coccyx or lumbosacral spine are not impinged by the bench. Breathe naturally while extending.

MODIFICATION
Use auxiliary suspension if necessary to hold the prosthetic leg on.

SKILL LEVEL
Advanced.

CAUTION
This exercise is not recommended for people with previous back injury. It is recommended only for those who have had previous conditioning in lower back exercises.



Albert Rappoport demonstrates the advanced position. He uses the ActivSleeve Suspension System for this exercise because the inner ribs prevent the sleeve from slipping on the thigh. Its rubber material stretches so that a full range of motion can be achieved.

EXERCISE 89. STIFF-LEGGED BARBELL DEAD LIFT

PURPOSE

Strengthens the muscles of the lower back.

PROCEDURE

- Roll the barbell to nearly touch your shins so that your feet are under the bar.
- Position your feet about shoulder-width apart. Do not bend your knees while doing the exercise.
- Bend from the waist and grasp the bar with an alternated hand grip (i.e., one palm facing toward you, the other away from you). The alternated hand grip is safest, especially when using heavier weights, because the bar is balanced and it is more difficult for the barbell to slip out of your hands. Hold the bar with your hands about shoulder-width apart, just outside the width of your feet.
- With legs and back straight, hands in position, and head up, inhale and lift the weight until you are standing erect.
- Pause momentarily, keeping your arms straight with no bend at your elbows. (Flexing the elbows decreases the strengthening effect on the back muscles.)
- Exhale as you lower the weight back to the floor, maintaining the straight-legged position. It is acceptable for your arms to slightly touch the sides of your legs while lifting and lowering the weight.

VARIATIONS

— If lifting straight-legged is too difficult, use the bent-knee technique for dead lifts, keeping the back straight, the knees slightly bent, and lifting with the thighs and back.
— For a more intense workout, do not rest the weight on the floor—only touch it down before lifting it back up.
— Another form of the Straight-Legged Dead Lift requires the person to stand on top of a weight bench or low platform in order to lower the weight to a level below the feet for a greater range of motion.

SKILL LEVEL

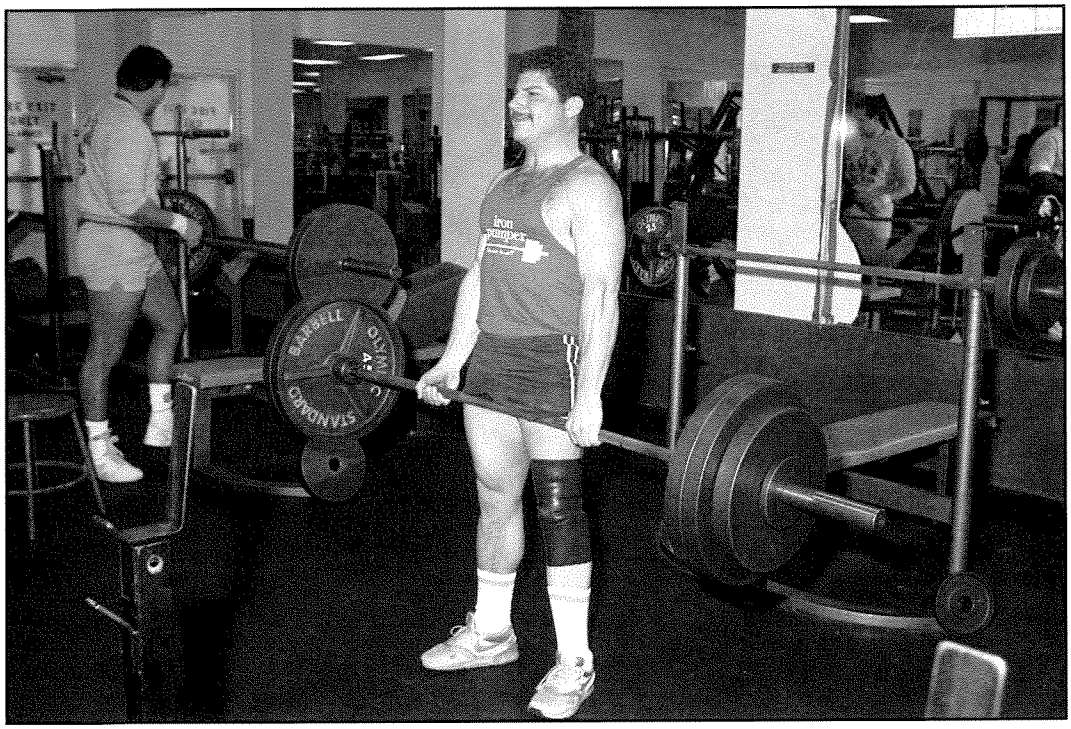
Intermediate to Advanced.

NOTE

Whenever lifting heavy weights, it is advisable to use a weight belt to prevent injury and to take some of the stress off the lower back. However, in the photographed demonstration no weight belt is used because the lifter is trying to emphasize his back muscles to a greater extent. Only experienced lifters should use this technique and do so with caution. The weights should be increased gradually and only if one trains on a regular basis. Remember, even experienced lifters can injure themselves by not warming up, by not following strict form, by not using a spotter, and by increasing the weight beyond their known capabilities.

CAUTION

This exercise is not recommended for those with previous back injury. Beginners should start with bent knees when lifting the barbell.



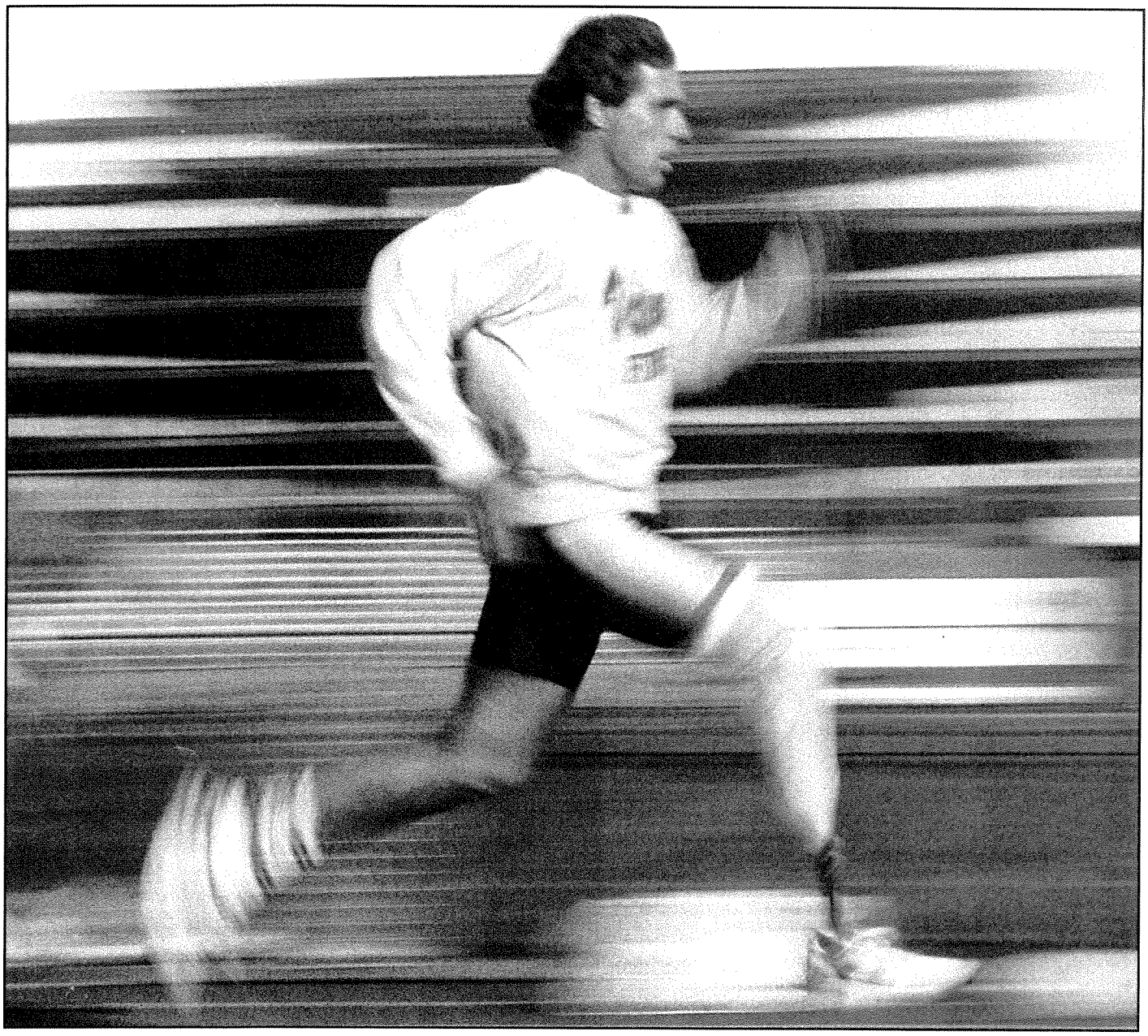
Albert Rappoport is working out with 305 pounds.

STEVE WILBER/SEATTLE, WA

Opponents face off in a game of crutch soccer.

PART THREE

ACTIVITIES FOR FITNESS AND SKILL



NEWSDAY/ J. CONRAD WILLIAMS, JR.

13

INTRODUCTION

Stretching, weight resistance, and aerobic exercises will develop and maintain physical fitness if done regularly. However, exercise routines are repetitious and may be tedious. Sports, on the other hand, are fun. Certain sports can also help participants to maintain fitness and improve overall strength and endurance. Active sports provide aerobic conditioning—the most important health benefit of exercise.

A balanced combination of flexibility exercises, weight resistance workouts, and active participation in sports builds aerobic endurance and strength in all major muscle groups, and creates proper muscle balance. While many sports require cardiovascular endurance, to excel in certain sports one should concentrate on exercises that focus on particular parts of the body. For example, in running, aerobic dance, or soccer, it is essential to develop strength in the legs and lower body; in rowing, emphasis is placed on strength and flexibility in the upper body, arms, and shoulders.

People who do not get enough regular exercise are not in adequate physical condition to participate in active sports without some preliminary aerobic conditioning. A person who is "out of shape" is not going to last very long on a cross-country ski trail, for example, nor will the experience be particularly enjoyable.

In the past, it was generally thought that a person with lower limb amputation could expect a greater amount of cardiovascular strain when engaging in active movements than would someone with two sound legs, because an artificial limb could not function as efficiently as a sound limb. Now, however, prosthetic adjustments or adaptive components can make artificial limbs quite responsive to athletic needs.

PROSTHETIC OPTIONS

Most exercises can be performed with or without the use of a prosthesis. In order to enjoy and successfully participate in sports, however, it is essential that one have a comfortable artificial limb that is suited to the activity. Activities such as walking, bicycling, and rowing often do not require any modifications or special adaptations to standard artificial limb components. However, runners usually require energy-storing feet and other prosthetic adaptations in order to improve performance and protect the residual limb; avid swimmers often use special waterproof prostheses. For any activity requiring lower limb movement, prosthetic units that provide knee stability and/or ankle mobility will be useful.

A general discussion of prosthetic components is presented below. Special adaptations for and modifications to these prosthetic components for particular activities are discussed in the chapters that follow. Most prosthetic components described here are explained in the Glossary.

The major components of a lower limb prosthesis are the socket, foot, ankle unit, and, for

above-knee prostheses, the knee unit. The choice of components, materials, and design varies with the needs of each individual.

The Socket

The socket is the most critical component of any prosthesis because it comes in contact with the residual limb. It should be both comfortable and functional. The residual limb must fit so that it is properly supported in the socket. The prosthesis must also be suspended on the body properly. If suspension is not adequate, pistoning can occur between the socket and limb interface, resulting in skin irritation that can lead to debilitating conditions and make it painful to even walk.

For those with BK amputations, the conventional patellar tendon-bearing (PTB) socket is generally not adequate for evenly distributed absorption of the force of impact that is generated during active sport participation. It is uncomfortable to run on a prominent patellar bar. A total surface-bearing socket provides for full contact and distributes the impact load over the greatest surface area. Side joints and a thigh lacer further reduce forces on the residual limb by transferring some weight to the thigh. This is especially helpful for individuals with very short or scarred residual limbs.

The ActivSleeve™ and Michigan Sleeve are latex rubber suspension sleeves that provide suction-type suspension and help reduce pistoning for the person with BK amputation. They may be used without additional support. A waistbelt attached to a cuff suspension socket can provide additional suspension within the socket to prevent pistoning. Suspension sleeves of neoprene are also useful in providing atmospheric suspension. The 3S (Silicone-Suction-Socket) provides excellent suspension and a socket interface that reduces shear forces and, for some individuals, can eliminate the need for straps or sleeves. The 3S suspension can also be used on AK and upper-extremity prostheses.

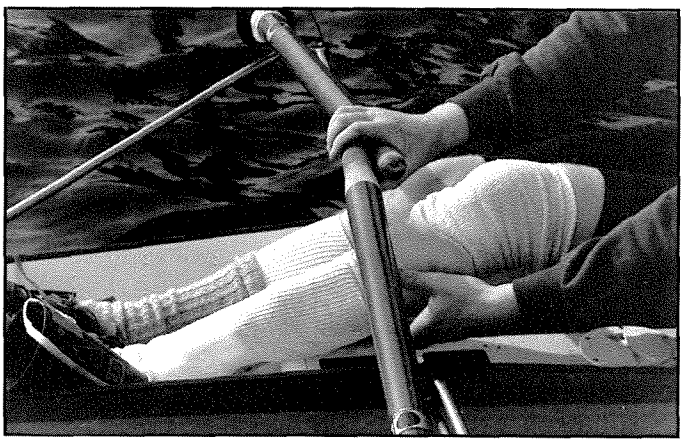
For those with AK amputation, the ischemia containment socket (also known as the Narrow M/L socket) design provides alignment stability and control of the femur. The Narrow M/L or Normal Shape Normal Alignment (NSNA) designed socket is also referred to as CAT-CAM (Contoured Adducted Trochanteric-Contained Alignment Method). A Silesian belt or Neoprene T.E.S. belt can provide auxiliary suspension to the AK suction socket, if needed. Many individuals find that it is more comfortable to run on a NSNA-style socket than on a quadrilateral socket because weight on impact is not placed on the ischial tuberosity. The flexible brim above-knee socket is also helpful in reducing stress on the residual limb.

Prosthetic Feet

The development of energy-storing feet is the greatest advance in prosthetic adaptations pertaining to running and any other sport requiring agility. With the aid of energy-storing feet, people with lower limb amputation are able to move quickly and run in the foot-over-foot gait. This is made possible by the presence of a flexible keel, which provides a spring action that simulates the push-off phase of running.

The SAFE (stationary attachment flexible endoskeletal) Foot, introduced in 1980, is considered to be the first modern energy-storing design. The VA Seattle Foot, developed in the early 1980s, was first made commercially available in 1985. The Flex Foot was also first released in 1985. Since then, a number of other energy-storing feet have been introduced. These include the STEN Foot, Carbon Copy II and III Foot, Quantum Foot, DAS Foot, Springlite Foot, and the Sabolich Foot.

A recent version of the SAFE Foot has a lightweight design using a totally flexible keel which offers a unique dynamic elastic response that functions well on uneven terrain. The Flex Foot and the Springlite Foot are made of lightweight graphite to create a strong push at toe-off. Because of this extra



STEVE WILBER/SEATTLE, WA

strong push-off capability, they are referred to as "super"-dynamic elastic response feet. However, proper alignment of the Flex Foot is critical in order for the leg to roll smoothly from heel-strike to toe-off. Most new wearers will need some time to adjust their gait to the spring action of this foot, but will find it excellent for fast-paced walking on even terrain.

For some activities, an energy-storing foot is not essential. A single-axis prosthetic foot (SACH) provides both plantarflexion after heel-strike and a smooth transition to mid-stance, thus increasing knee stability, particularly for the walker with AK amputation. For this reason, a single-axis unit can also be useful to a person with a short residual limb below the knee or with a knee with flexion contracture.

In addition to plantarflexion at heel-strike, a multi-axis foot provides motion in dorsiflexion, inversion, and eversion. These features help the walker deal with uneven terrain. A multi-axis foot can also make walking on even terrain more comfortable because the foot conforms well to the ground surface. The current versions of the SAFE Foot, Greissinger Foot, Dynamic Foot, Endolite, Quantum, IPOS 6-way Foot DAS, and DAW feet provide excellent multi-axis function. The SAFE Foot, DAS Foot, and Quantum Foot also offer energy-storing capabilities. The energy-storing keel of the SAFE Foot is also flexible, giving it dynamic elastic response. One of the newest multi-axis foot systems is called the Carbon Copy System III, which combines an energy-storing foot and combined rotational pylon unit.

Ankle Units

Newly developed ankle components, such as the Seattle Ankle, MARS Unit, Multiflex Endolite Ankle, or SwePro Ankle, can provide for a wide range of motion and increased flexibility. An energy-storing foot that does not have a multi-axis function can be coupled with an ankle to acquire range of motion. Most new ankle units can be adapted to the Seattle Foot, Sten Foot, Carbon Copy II, Flex Walk Foot, or other prosthetic feet that are similar in design. The ankle is mounted inside the foot in a position that closely resembles the anatomy of a real foot.

Knee Units

The knee joint of an AK prosthesis should allow for stable and safe operation and ease of extension, and should be lightweight. Hydraulic knees, such as the Mauch SNS Knee Unit, provide for stance and swing control, which enables stability on single limb support, particularly when running. The redesigned Otto Bock hydraulic unit also provides excellent swing and stance control and is lightweight. The Endolite Stabilized StanceFlex (Bouncy) Knee is another knee unit that is excellent for use in active sports. This knee unit can be combined with other prosthetic systems to improve mobility, and is discussed in further detail in the chapter on running.

SKIN CARE

Proper skin care is absolutely necessary for active individuals. Blisters and other irritations to the residual limb can be prevented by regular use of products that reduce shear forces and cushion vulnerable areas.

Practicing good hygiene of the residual limb and socket will help prevent skin problems. Socks should be changed when they become wet. Determining the right number of socks to wear is important: too few or too many can result in skin irritations and blisters. If blisters occur, vitamin E oil or *Aloe vera* are excellent aids for healing the skin. Spenco™ 2nd Skin™, Spenco™ Skin Care Pads, DuoDerm from Squibb, and Johnson & Johnson Bioclusive® Pads are also helpful. The Hood Socket Cleaning Kit is useful in making the job of socket care easier. If sweat is a problem, the Drionic device from General Medical can be useful.

SELECTION OF ACTIVITIES

The activities presented in this section can be categorized as follows:

1. Individual sports that produce vertical impact on the residual limb (i.e., walking for exercise, running, and aerobic dance). Usually, no previous skill is needed to participate. High-level strength and endurance are not essential for beginner participation and aerobic benefit.

2. Individual sports that are relatively nontraumatizing to the residual limb (i.e., swimming, cycling, rowing, and cross-country skiing). For adequate aerobic benefit, good skills in swimming, cycling, and rowing are needed. High-level skill, strength, and endurance are needed to achieve adequate aerobic benefit in cross-country skiing.
3. Game sports, which usually involve vertical impact and stresses to the residual limb (i.e., handball, racquetball, tennis, squash, basketball, soccer, hockey, and lacrosse). These and most other game sports will require a moderate skill level for adequate aerobic benefit. Game sports are often considered supplemental options rather than integral parts of the total physical fitness program.

Jeff Keith arrives in Los Angeles after completing a 3-month run across the United States.

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WALKING

Walking is the most natural form of aerobic exercise. It is also the most gentle. It does not place undue stress on the musculoskeletal system, because one foot is always in contact with the ground. Unlike other forms of exercise, walking can be combined with the daily living routine. It does not require any special training, skills, or equipment.

Although walking is basic to almost everyone, there are certain techniques that will enhance its aerobic benefit.

- Maintain an upright posture with shoulders back and head held up.
- Let the upper body do some of the work by swinging the arms in coordination with the legs.
- Land on the heels of the foot and push off with the toes.
- Establish a comfortable consistent rhythm.

The aerobic benefits of walking will be further improved by increased pace, length of stride, and distance walked.

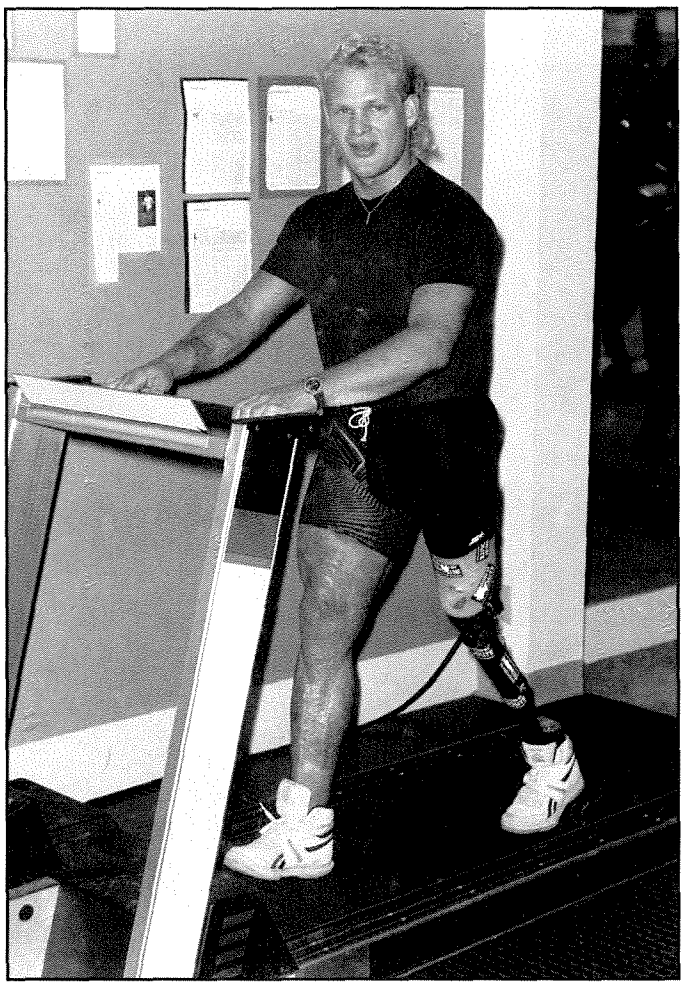
The only equipment needed for walking as an exercise is good shoes (these are especially important for a person with a unilateral amputation, since much stress is placed on the sound limb). Special shoes for pace walking are a somewhat recent development but, like running shoes, may be found in most sporting goods stores. Two important features to look for in walking shoes are firm heel support and a flexible forefoot. Walking shoes should fit comfortably even when new.

The prosthetic components selected for everyday use will generally be suitable for walking as an aerobic exercise. Most prostheses are designed primarily for standing and walking. On occasion, some modifications or separate prosthetic components may be needed. Additional suspension may be needed, and energy-storing feet are an advantage for most individuals. A single-axis foot or the combination of a multi-axis ankle with an energy-storing foot is good for walking down hills and provides for increased knee stability.

A person with lower limb loss who is comfortable standing and moving about with a prosthesis will find that walking is excellent for beginning and maintaining an aerobic conditioning program. However, some people do experience difficulties as the result of surgical, prosthetic, or musculoskeletal problems. In such cases, the physician, prosthetist, and therapist may be able to solve these problems by prescribing a new limb, therapy, or surgery. If these options are not feasible or successful, there are other forms of aerobic exercise that are even less stressful to the residual limb. Swimming, bicycling, or rowing, for example, can be beneficial even without the use of a prosthesis.

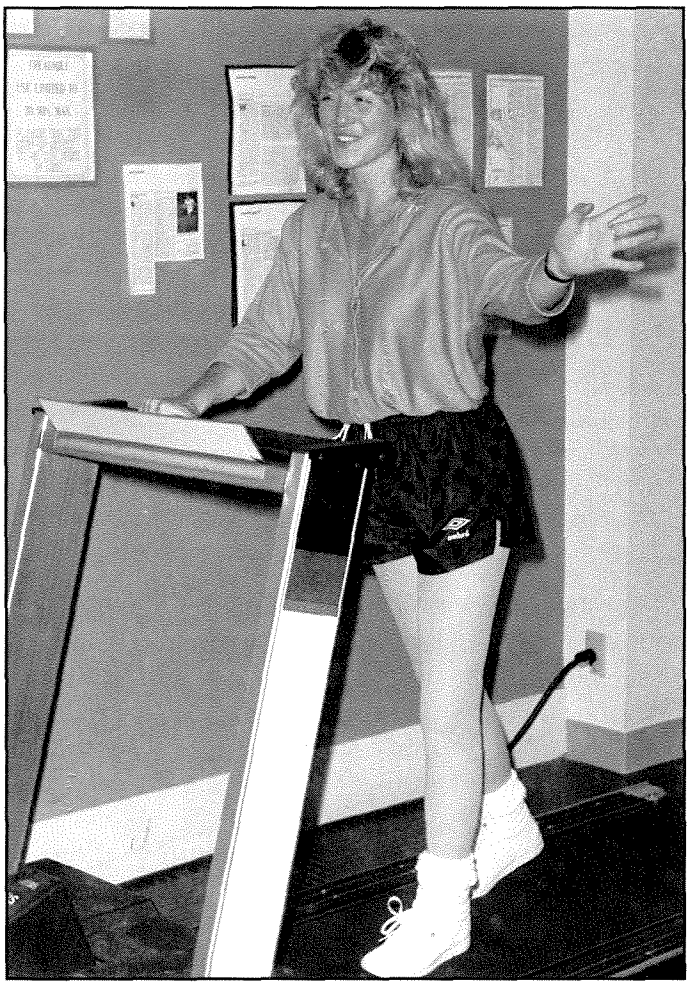
STATIONARY MACHINES

Exercising on a treadmill walking machine is a good way for a person with lower limb loss to train for outdoor walking. It is also an excellent way to warm up and exercise for someone who is just



DALE TILLY/VAMC SEATTLE, WA

Distance and time can be monitored while walking on a computerized treadmill. It is best to hold on to the hand grips when beginning in order to establish balance.



DALE TILLY/VAMC SEATTLE, WA

A motorized treadmill can be an excellent method of achieving aerobic fitness for skilled individuals with bilateral AK amputations. The self-propelled walkway creates a controlled environment that can be monitored. Speed of the walkway can be gradually increased. It is helpful to hold on to the hand rails and use caution getting on and off the moving belt.

beginning a fitness program. A digital computerized motor-driven treadmill is best to start with, because it is easier to walk on than are many of the self-propelled models.

However, a constant pace must be maintained in walking on a treadmill machine, and the base of support must remain within a specific area. This takes good balance and can be difficult for some people wearing a prosthesis. For best results when first using a treadmill, the machine should be set for a slow pace and gradually adjusted to a faster pace.

Getting on and off the treadmill may also be difficult for the prosthesis wearer, so one should practice until balance can be maintained easily. A side railing for hand support will provide added safety in addition to the single handbar in front of the walkway.

Treadmill training has advantages over outdoor walking for the prosthesis wearer. If there is pain or an irritation of the residual limb due to exercising, one does not face the prospect of having to walk back to the starting point, thus causing further irritation. One can get off the treadmill, adjust the prosthesis and, if necessary, discontinue exercising until an adjustment can be made by the prosthetist. Also, in many cases, the treadmill "gives" a little with each footfall. This helps cushion the impact to

the residual limb. This is why some people prefer walking on the treadmill to walking outdoors.

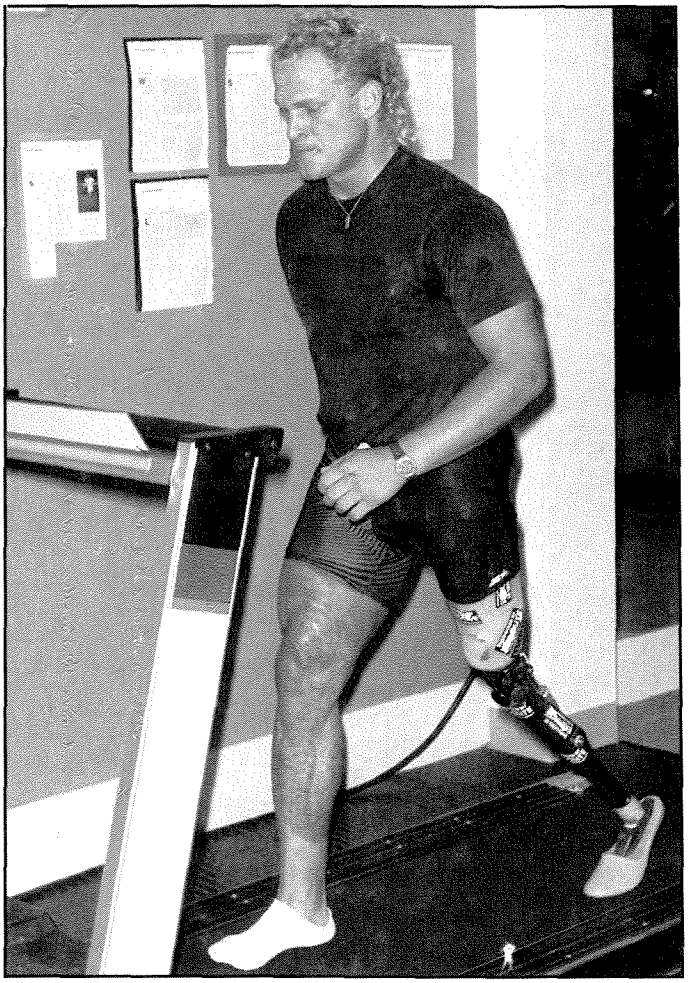
The "distance" covered on the treadmill should be gradually increased. Once stamina is built up and prosthetic problems, if any, are solved, walking outdoor distances will be safe and enjoyable.

DESIGNING A WALKING ROUTINE

Walking for exercise, whether accomplished outdoors or on a treadmill, should be approached in a manner similar to other types of aerobic sports. Walkers should start slowly and gradually build up time, distance, and speed over a predetermined number of weeks of training. The American College of Sports Medicine recommends that the minimum amount of exercise needed to maintain good aerobic health is 20 minutes, three to four times per week. Walkers should work up to a combined total of about 3 hours a week, walking at a pace that maintains the heart rate in the targeted zone of 70-85 percent of 220 minus their age. (See pp. 24-25 in Chapter 4.)

It is important for a beginner to monitor his or her pulse rate. If the pulse rate during a workout is above 85 percent of maximum, the walking pace should be slowed. If the pulse rate is well below 70 percent, the walking pace or the rate of the arm swing should be increased. It is beneficial to keep a log of pulse rate at the beginning, middle, and end of each workout. The length of recovery time after each walk should be noted along with the amount of time walked and the distance covered. (Recovery time is the time it takes for the pulse to return to its normal rate after one exercises. As physical condition improves, the recovery time shortens.) More experienced exercisers will not need to monitor the heart rate regularly. They will be able to feel it when they are exercising within their target range.

Some individuals, particularly older people, may find they cannot maintain their heart rate at 70-85 percent of maximum for as long as 20-30 minutes. In this case, similar fitness levels can be achieved by exercising at a lower intensity level for a longer period of time. For example, a person may work to achieve 60 percent of maximum heart rate for 40 minutes or 50 percent of maximum for 50 minutes.



DALE TILLY/VAMC SEATTLE, WA

With practice, a steady pace will improve the aerobic benefits of the treadmill. The graphite Endolite prosthesis shown has a CAT-CAM Suction AK socket, polyethylene inner socket, and polypropylene outer frame attached to the Endolite Stance Phase Flexion Stabilized Knee, Mauch Swing Phase Hydraulik Knee Unit, Endolite Bouncy Knee, Endolite Multiflex Ankle, and graphite foot.

Three hours of walking per week is generally adequate for most individuals to maintain good aerobic fitness. Certainly one can gain additional benefits by training for more than 3 hours a week, but it is not necessary unless one is interested in competitive activities. It is best for beginning walkers to train every other day with a rest day in between. This allows the muscles to relax and recover. In the beginning, it is more important for the walker to concentrate on the length of time he or she is able to maintain the target heart rate than to be concerned with distance covered. As strength and

stamina are improved, those who wish to may walk briskly for exercise every day.

Walking for aerobic fitness is more demanding than ordinary walking; warm-up and stretching exercises before and after walking will help prevent muscle soreness. Even with such exercises, as speed is increased and the arm swing becomes more vigorous, muscles in the legs, upper arms, and shoulders may become sore. If soreness is problem, one should progress at a slower rate.

AP/WIDE WORLD PHOTOS

Jeff Keith, right, is shown at the beginning of his successful cross-country run in Boston on June 4, 1984. With him is his friend, Ted Kennedy, Jr. (left), who ran along for the first mile. Keith, who lost his leg to cancer, said he made the run to prove that "disabled" does not mean "unable."

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RUNNING

Running is one of the most efficient ways to achieve aerobic conditioning. It can also be one of the most difficult activities for a person with lower limb amputation.[1] Running requires foot-over-foot movement and causes musculoskeletal stress from the impact of landing. Many individuals wearing prostheses can comfortably sprint and run short distances; however, running long distances presents an entirely different situation. Long-distance running requires a high degree of personal motivation. For those with lower limb amputation, it also requires a properly designed prosthesis and a residual limb that is able to withstand the substantial forces generated by the impact of landing.

Over the past decade, the accomplishments of several runners with lower limb amputations have provided motivation and inspiration for others. Some have completed ultra-marathons, such as Terry Fox, who at age 19 logged up to 30 miles a day to make a 3,330 mile run across Canada in 1980. In 1985, Steve Fonyo, also 19, ran nearly 5,000 miles across Canada. In the same year, 21-year-old Jeff Keith ran 3,300 miles across the U.S., wearing the recently developed Seattle Foot.

Not only the young have become outstanding runners. In 1982, Bart Van Housen, at age 35, ran over 900 miles from the Oregon border to Mexico. Robert Kerrey, Congressional Medal of Honor recipient (Vietnam) and U.S. Senator from Nebraska, runs 5 miles a day. Ray Mann, a Vietnam veteran, has run a marathon (26.2 miles) in under 4 hours using the Seattle Foot.

RUNNING IS NOT FOR EVERYONE

Running is a strenuous form of exercise. It can sometimes cause debilitating problems with regard to skin, muscles, ligaments, and tendons in the legs. Therefore, running as exercise should be carefully considered by those with lower limb loss. Factors that affect the ability to run are the nature of the surgery, the level of amputation and the condition of the residual limb, the prosthetic fitting, the general state of physical fitness, and personal motivation.

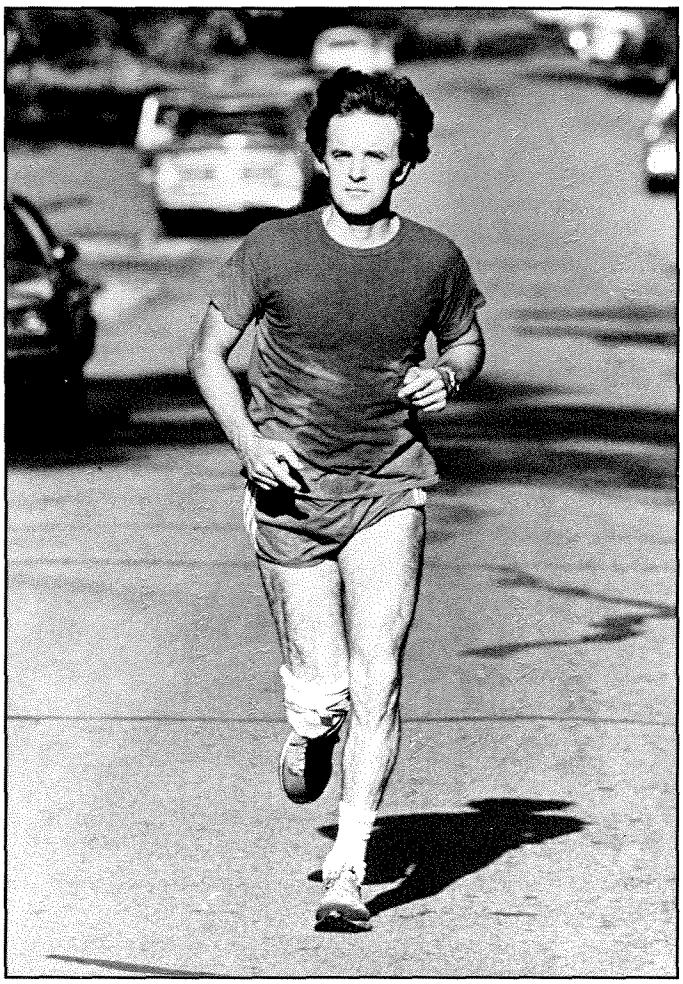
It is recommended that everyone, particularly those over age 35, consult a physician before starting a running or jogging program for fitness and conditioning. Once medical approval has been obtained, individuals who have not previously exercised should proceed with moderation. Before a new prosthetic leg is built, anyone with lower limb amputation considering running should inform the prosthetist so that he or she can design it with that in mind. If running or jogging causes any pain or irritation, the prosthetist should be consulted immediately.

Most individuals will not be able to run or jog for extended distances and time without periodic irritation to the residual limb. Alternative aerobic activities may be better for those who experience persistent residual limb irritation. Activities such as walking, swimming, or bicycling are less traumatizing to the residual limb.

RUNNING SURFACE

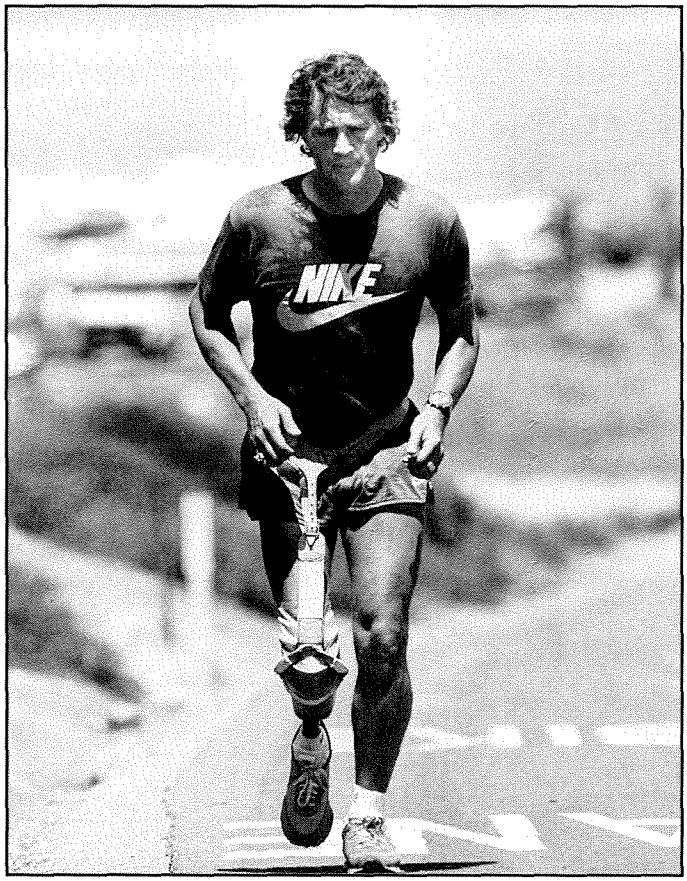
The running surface substantially affects the ability to run. Running on grass does not cause stress to the body as much as running on a concrete or asphalt surface. For the runner with lower limb loss, however, grass may be more difficult. The surface is not always even; rocks and holes can throw a runner off balance, causing irritation to the residual limb. Running on grass also tends to dampen the push-off built into energy-storing feet. Even with these problems, some runners prefer grass because it lessens the shock to the body.

In contrast to grass, a concrete surface provides a platform for the spring in the energy-storing foot to react with greater intensity, since nothing is lost by the force absorption of the ground reaction.



TED KIRK/LINCOLN, NE

Senator Robert Kerrey is shown on one of his daily 5-mile runs. He uses the same prosthesis for walking and running.



AP/WIDE WORLD PHOTOS

Bart Van Housen is shown as he nears the completion of his run from the Oregon border to Mexico in 1982. He made the run to raise funds for the Easter Seal Society.

Thus, a hard, even surface is often preferable to grass because it is a consistent surface, permitting the runner to land the same way each time.

Many recently constructed running tracks have tartan turf or a hard rubber surface. This may be the best type of track for disabled runners because the material is slightly forgiving, yet it has an even surface.

Treadmills provide an even surface that absorbs some of the landing impact. The treadmill is also excellent for practicing and improving the foot-over-foot running technique and for cardiovascular training.

ENERGY-STORING FOOT DESIGN

Runners with leg amputations have run for years prior to the development of energy-storing

THE WINKLEY CATALOG

Running foot-over-foot using conventional prostheses of the late 1940s and early 1950s was possible for short distances but not very comfortable.

feet. But because their prostheses provided no spring and lift, running was painful and induced great trauma to their residual limbs and throughout their bodies. Energy-storing feet provide comfort as well as improved performance. They have helped to make it possible for an athlete such as Dennis Oehler to run the 100-meter dash in 11.73 seconds at the 1988 Paralympics in Seoul, Korea, and for Jim MacLaren to complete the 1988 New York Marathon in 3 1/2 hours, the fastest recorded time for a marathon runner with an amputation.

The Seattle Foot and the Carbon Copy II Foot are energy-storing feet that are particularly well suited to running because of their responsiveness, light weight, and adaptability to many conventional prostheses. The Flex-Foot is excellent for distance running as well as sprinting. It represents the maximum in energy storage potential.[2] The Flex-Foot is one of the lightest weight prosthetic feet available. The Springlite Foot and the Carbon Copy System III are recently developed energy-storing feet that are made of carbon fiber material.

BELOW-KNEE PROSTHETIC ADAPTATIONS

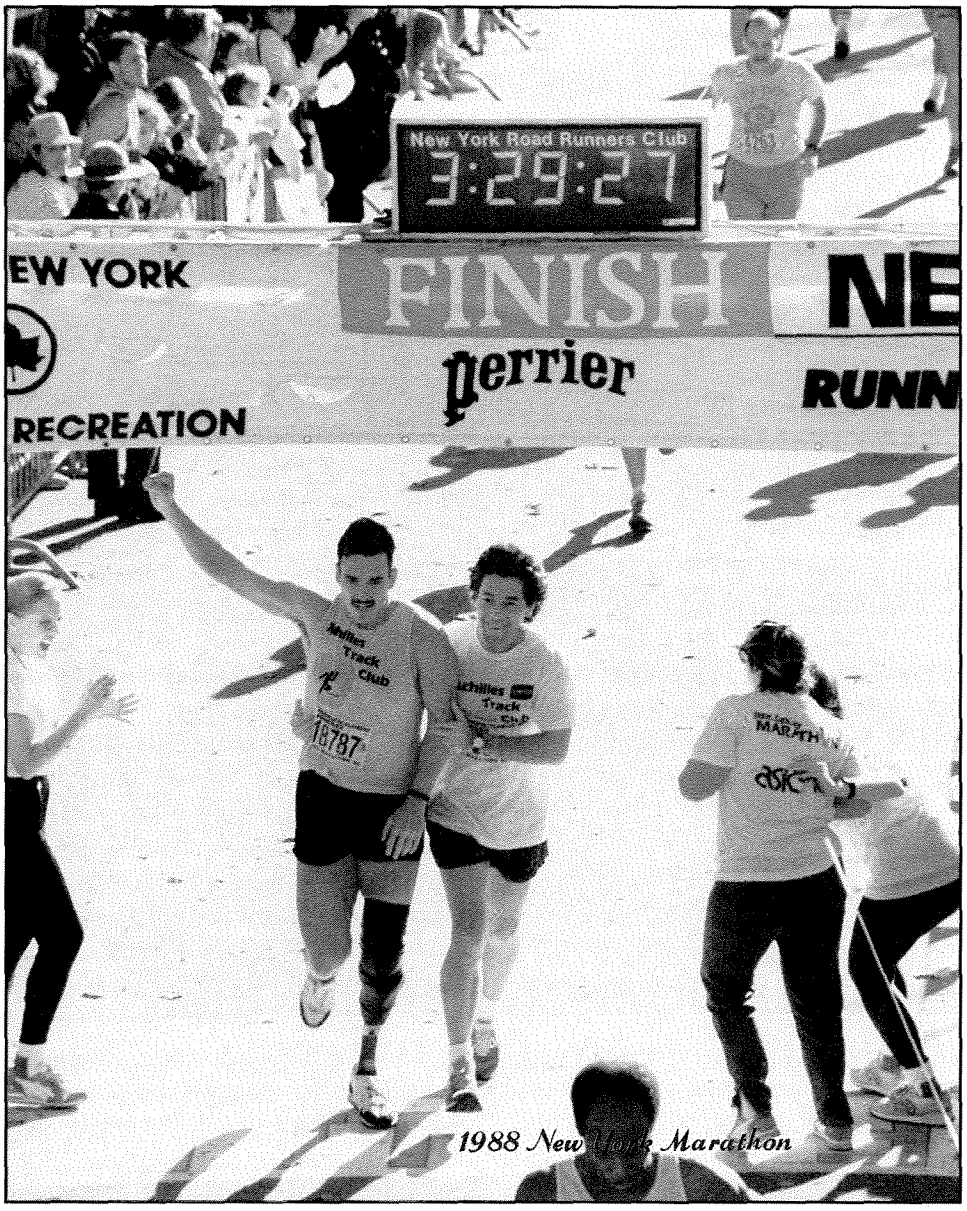
The weight of the entire BK running prosthesis should not exceed 3 pounds. Components fabricated from Kevlar, fiberglass, Spectralon epoxy, and acrylic resins, as well as from plastics, graphite, or titanium can provide for strong, lightweight limbs that weigh from 2 to 2 1/2 pounds. Improvements in suspension methods help lighten the sensation of weight of the prosthesis. For example, a cuff strap can be enhanced by adding a neoprene suspension sleeve over it or by adding a waistbelt. A latex rubber or neoprene sleeve by itself can also be added as an auxiliary suspension to a supracondylar prosthesis or patellar tendon-bearing (PTB)-style BK prosthesis. The 3S silicone suction socket and Icelandic Roll-on Suction Socket (IceRoss) are new methods of BK suspension which use no straps, belts, or sleeves.

To help protect the residual limb while running, a nickleplast liner with selectively placed silicone gel,[3] a complete silicone gel liner with horsehide,[4] injection-molded silicone liner,[5] or the PM Liner help reduce the shear forces associated with skin breakdown. Silicone end pads also help absorb impact and prevent possible injury to the distal end of the residual limb.

Because there is great impact on the limbs as they land on the ground, weight must be distributed evenly through the socket of the artificial limb. In designing a socket for a potential runner, the use of multiple, clear diagnostic sockets and alginate impression material helps to ensure a total contact fit for even distribution of pressure.[6] Some may find that they need to add side joints and a thigh lacer to further reduce forces on the residual limb by some transfer of weight to the thigh. This also may help prevent skin breakdown. Some runners, however, will find these additional components restrictive and cumbersome. Once the socket is constructed, the runner should exercise on it and slowly increase the running distance covered. Any problems should be resolved prior to making the finished prosthesis.

Anterior Distal Tibia Problems

A common problem among runners with BK amputations is excess pressure on and possible skin breakdown over the distal anterior portion of the tibia. The tibia is the larger of the two major bones



MARATHON PHOTOS

Jim MacLaren crosses the finish line of the 1988 New York marathon. In addition to breaking records in running, he holds records in triathlon events.

in the leg. In a person with a BK amputation, the anterior distal portion is the lower front section of the tibia in the residual limb.

Jogging is usually characterized by a gait pattern that extends the knee so that the foot lands first on the heel. However, running patterns show that people usually land on their forefoot when sprinting. The forces that control the knee from heel strike to foot flat result in the residual limb extending into the socket as the knee is flexing in order to control the prosthesis. Thus, there is greater danger of developing pressure and possible skin breakdown when landing heel first. A foot that provides plantar flexion will help control the knee and greatly lessen the forces on the anterior distal tibia. However, landing on the forefoot is usually best.

Socket Fit and Suspension. One way to help prevent skin breakdown at the tip of the tibia is to ensure a comfortably fitted and accurately contoured socket. A loose-fitting and ill-contoured socket with incorrect suspension can result in fric-

TIMOTHY B. STAATS, PhD, CP/UCLA PROSTHETICS-ORTHOTICS EDUCATIONAL PROGRAM

Alginate is used inside of the clear diagnostic check socket to create a total contact fitting for a below-knee residual limb.

TIMOTHY B. STAATS, PhD, CP/UCLA PROSTHETICS-ORTHOTICS EDUCATIONAL PROGRAM

A clear diagnostic check socket is used with atmospheric suspension.

tion and, if not corrected, cause skin breakdown. Two ways to correct the problem are by: 1) providing adequate relief over the distal end of the tibia; and, 2) loading either side of the tibial bone with increased pressure in the socket to keep the tip of the bone from hitting against the socket. Making the posterior walls of the socket high keeps pressure counter-balanced on the anterior distal tibia as it is extended in the socket. This will prevent the tibia from cantilevering between heel strike and foot flat, which could cause the anterior distal tibia to be driven into the front wall of the socket.

Another way to prevent anterior distal tibia problems is by changing the materials used in the socket. A flexible inner socket material, such as stress-relieved polyethylene, can be used with rigid outer socket material, such as polypropylene. When the outer rigid socket is cut out over the distal end of the tibia, leaving the flexible insert exposed, pressure is relieved. This concept may be used for flexibility in other areas of the socket as well, so long as the socket structure is not weakened.

A prosthetic nylon sheath can be placed underneath the sock to help reduce friction. This allows the prosthetic socket to slide over the sheath rather than over the skin, which can sometimes lead to skin breakdown. Some runners use two or three sheaths at a time to help reduce shear forces on the skin and help to "wick" off perspiration. Also, runners who know that their skin breaks down in the same place each time they run should use skin care pads or Second Skin (among other products) as a preventive measure by putting them over these areas before they run.

Gait Patterns/Prosthesis Design and Alignment. Landing on the heel rather than the ball of the foot is often caused by the alignment of the artificial limb. For someone with BK amputation, a heel-toe gait is not harmful in walking, but in running or jogging it causes excessive force on the anterior distal portion of the tibia. Anterior distal tibia problems caused by a heel-toe gait can be alleviated by using a prosthetic foot that allows for easy plantar flexion. At heel strike the foot should drop quickly toward the ground. This prevents the need for knee flexion to control the leg from heel strike to foot flat. The addition of the Endolite MultiFlex Ankle or the Seattle Ankle MultiAxial Rotation (MARS) unit is excellent to accommodate the running pattern.

The Solid Ankle Cushion Heel (SACH) foot, with a soft heel cushion, is a single-axis foot that provides for plantar flexion. It was designed to help stabilize the knee and make walking smooth and natural. Unfortunately, it is not good for running since it is not energy-storing. The Flex-Foot is similar in reaction to a single-axis type of foot when the softer heel is chosen for the runner's weight and for the distance run.

Most energy-storing feet do not have a true single-axis design, but some, when combined with additional ankle components, can provide an active form of plantar flexion. The Seattle Foot, Carbon Copy II Foot, SAFE Foot, STEN Foot, and Otto Bock Dynamic Foot are energy-storing or have dynamic elastic response and can be combined with a compatible ankle unit. The use of Endolite's Multiflex Ankle or the MARS unit on any of these feet will enhance their multi-axis function for running. The Seattle Ankle, when added to any of these feet, also provides a degree of active plantar flexion, which helps reduce anterior distal tibial pressure. (In this case, plantar flexion is the act of lowering the foot from heel strike to foot flat.)

The DAS (Dual Ankle Spring) Foot develops its energy storage release from the compression of an anterior spring and offers ease of plantar flexion from the posterior spring compressing.[7] The combined anterior/posterior spring also offers a multi-axis function. It is excellent for sprinting off the toe section because the keel extends to the end of the foot, thus enhancing running speed.

Because anterior distal tibial problems can occur from jogging when a person lands with an extended knee at heel strike, it is preferable to land on the ball of the prosthetic foot or on the toes (as a runner or sprinter does). Thus, many joggers naturally take on this pattern of running with knee flexion to land on the toe section as a self-protective mechanism, in order to prevent pain resulting from excess pressure on the anterior distal tibia. Although jogging with a flexed knee may not look as nice as running with long strides, it may be the only way for some individuals to run long distances without causing problems to the anterior distal tibia.

Running with the knee slightly flexed helps one land on the ball of the foot. However, if the quadriceps muscles are weak, it can be difficult to land on the ball of the foot with a flexed knee. In this case, a cuff strap that holds the knee in flexion helps maintain the leg in the desired degree of flexion. The cuff strap may be combined with a suspension sleeve for additional support. A suspension sleeve alone does not hold the leg in flexion while running, but it will be adequate for those with strong knees and quadriceps muscles. The addition of side joint and lacer may also be needed for some individuals.

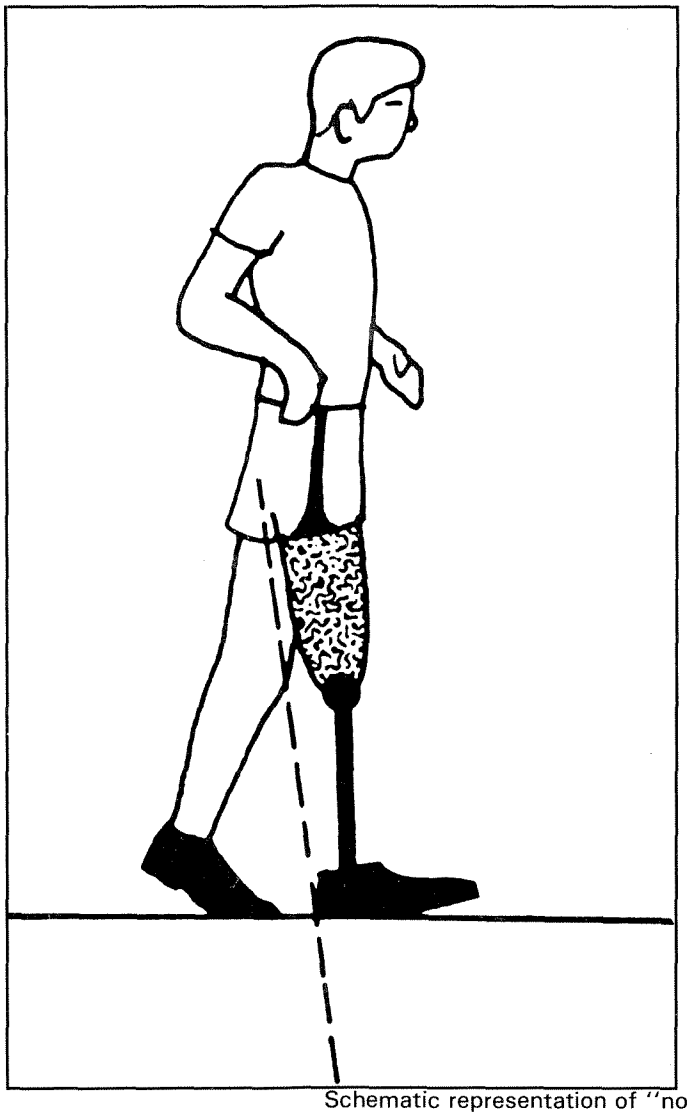
Summary. Each person's residual limb is unique and each prosthesis may require special adaptations. An artificial leg used for walking may never result in anterior distal tibia problems. The walking alignment often can also be used for running, but some individuals will require a special leg with a running alignment. Two common changes made for a running leg alignment are increased toe-out to compensate for greater internal rotation at the hip, and a longer toe lever on energy-storing feet to provide a stiffer spring rate for an increased push at toe-off. Some prosthetic legs aligned just for running force the runner to land on the ball of the foot.

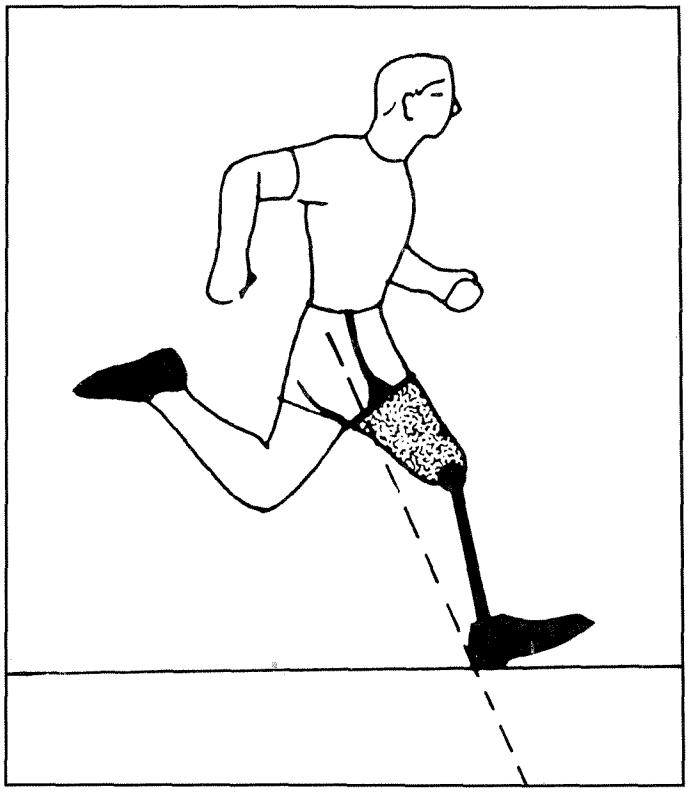
Options to consider to help prevent anterior distal tibia pressure are summarized below:

1. a well-fitting BK socket/total contact/surface-bearing socket (non-prominent patellar bar, if any);
2. socks with no more than 5-ply thickness;
3. sheaths to reduce shear force;
4. an even load on both sides of the tibia on the medial flare and pre-tibial compartment along with a posterior wall high enough to prevent cantilevering;
5. a flexible socket liner and a rigid outer frame cut out over the crest of the tibia or other pressure areas;
6. full gel liner or selectively placed gel over distal tibia;
7. a prosthetic foot and ankle that will provide plantar flexion from heel strike to foot flat;
8. flexed knee gait (optional cuff suspension for landing on the forefoot);
9. preventive skin care using Spenco™ 2nd Skin™ and Spenco™ Skin Care Pads or Johnson & Johnson Bioclusive® Pads.

ABOVE-KNEE PROSTHETIC ADAPTATIONS

Two main characteristics of running that make it different from walking present a challenge for





G. MENSCH AND P.E. ELLIS/'RUNNING PATTERNS OF TRANSFEMORAL AMPUTEES: A CLINICAL ANALYSIS,' PROSTHETICS AND ORTHOTICS INTERNATIONAL, V. 10, 129-134, 1986. REPRINTED WITH PERMISSION

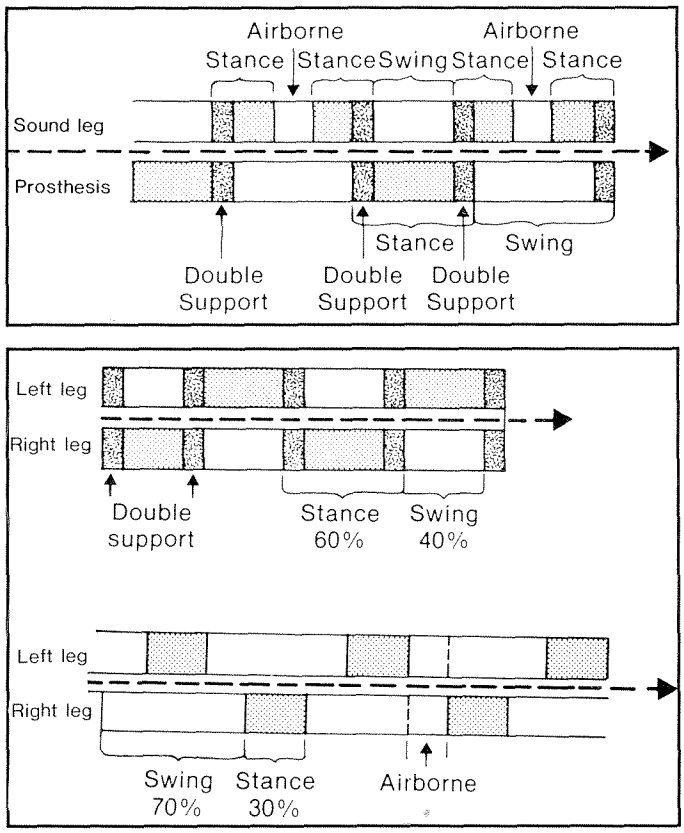
Schematic representation of "normal" foot-over-foot running cycle.

people with AK amputation. First, the increase in velocity causes the stance phase to make up only 30 percent of the gait cycle, while the swing phase accounts for 70 percent. Second, in normal foot-over-foot running, both feet are off the ground simultaneously for a short period of time.

Foot-Over-Foot Versus Hop-Skip Running

Individuals with AK amputations have had great difficulty running in a normal foot-over-foot fashion because the impact at heel strike must be absorbed by knee flexion. Conventional AK prosthetic components do not provide a great deal of knee flexion. Without knee flexion, one must use a hop-skip method of running.[8] In the hop-skip method, both legs cannot be off the ground simultaneously. A double-stance phase takes place when the sound leg makes the second hop. The extra second hop gives the time needed to get the prosthesis out in front. The hop-skip method causes the legs to be close together at heel strike, which lessens the impact when landing on the prosthesis and decreases the knee flexion moment. The hip is also in a better position to extend the residual limb to further control the tendency for increased flexion of the knee.

The hop-skip pattern was used by Terry Fox during his 1980 run across Canada to raise funds for research of cancer, the disease which caused him to lose his leg. His original idea to use a spring to absorb the shock was developed after his death. A



G. MENSCH AND P.E. ELLIS/'RUNNING PATTERNS OF TRANSFEMORAL AMPUTEES: A CLINICAL ANALYSIS,' PROSTHETICS AND ORTHOTICS INTERNATIONAL, V. 10, 129-134, 1986. REPRINTED WITH PERMISSION

Schematic representation of the hop-skip cycle.

prosthesis using the spring idea was designed to help many people with AK leg loss by alleviating ground impact and allowing for comfortable foot-over-foot running. It is called the Terry Fox Running Prosthesis, and can be combined with a conventional quadrilateral socket.[9]

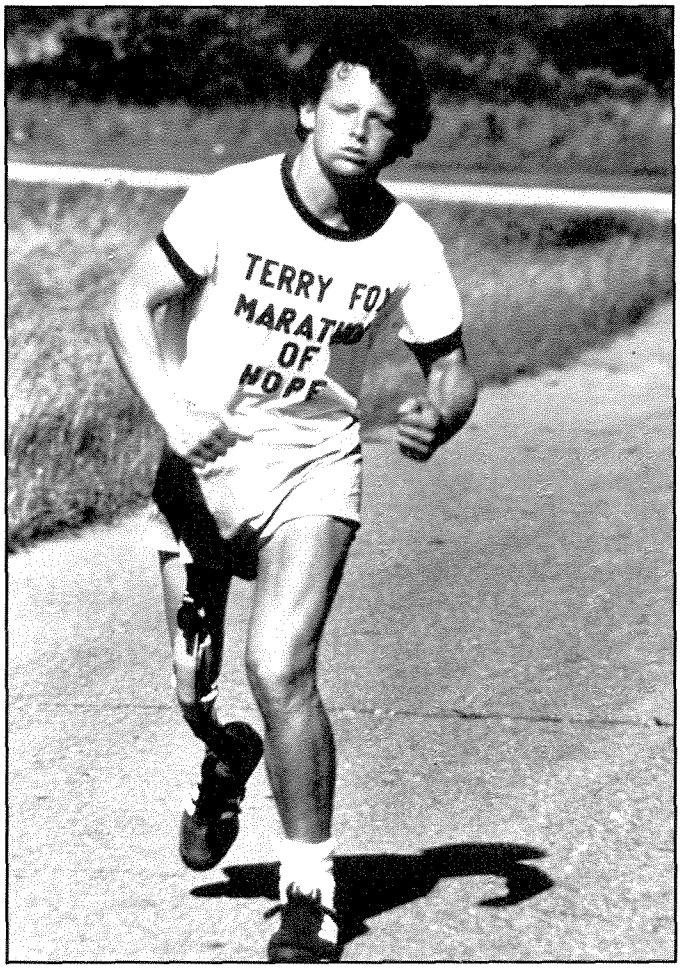
Impact at heel strike is alleviated by the Terry Fox Running Prosthesis through the spring shaft, which compresses and cushions the impact to the residual limb. From heel strike through mid-stance the spring is compressed to shorten the prosthesis slightly and lower the center of gravity. As the runner rolls over the toe, the spring is released, weight is taken off of it, and energy is released at toe-off, which moves the prosthesis forward into swing phase.

Socket Design and Other Components

Socket fit is the most critical feature of the AK prosthesis for a runner. As with socket design for BK prostheses, clear diagnostic sockets with alginate impression material helps to ensure a total contact fit for even distribution of pressure. Injection-molded silicone gel in selected locations of the socket reduces shear forces and provides additional shock absorption, particularly for the quadrilateral socket wearer.[10]

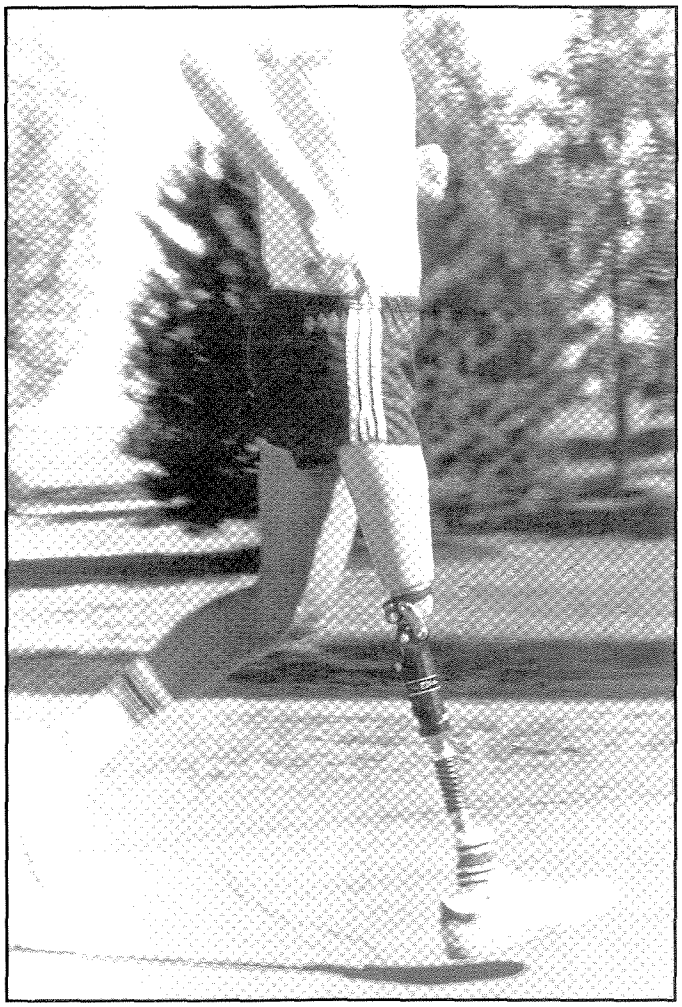
Foot-over-foot running is improved through combining CAT/CAM or Narrow M/L sockets and Stance and Swing Phase knee units with energy-storing feet. Components designed for foot-over-foot running are made of lightweight plastics, graphite-epoxy composite, and titanium. A flexible brim socket adds comfort by providing a more forgiving material on heel-strike impact.

New socket designs providing ischial containment also enable foot-over-foot running. In these new designs, the ischial tuberosity is contained in the socket instead of resting on a posterior shelf as in



THE CITIZEN/OTTAWA, ONTARIO, CANADA

Terry Fox is seen on his famous run across Canada.



GERTRUDE MENSCH, RPT/HAMILTON, ONTARIO, CANADA
The Terry Fox Spring Shank Running Leg.

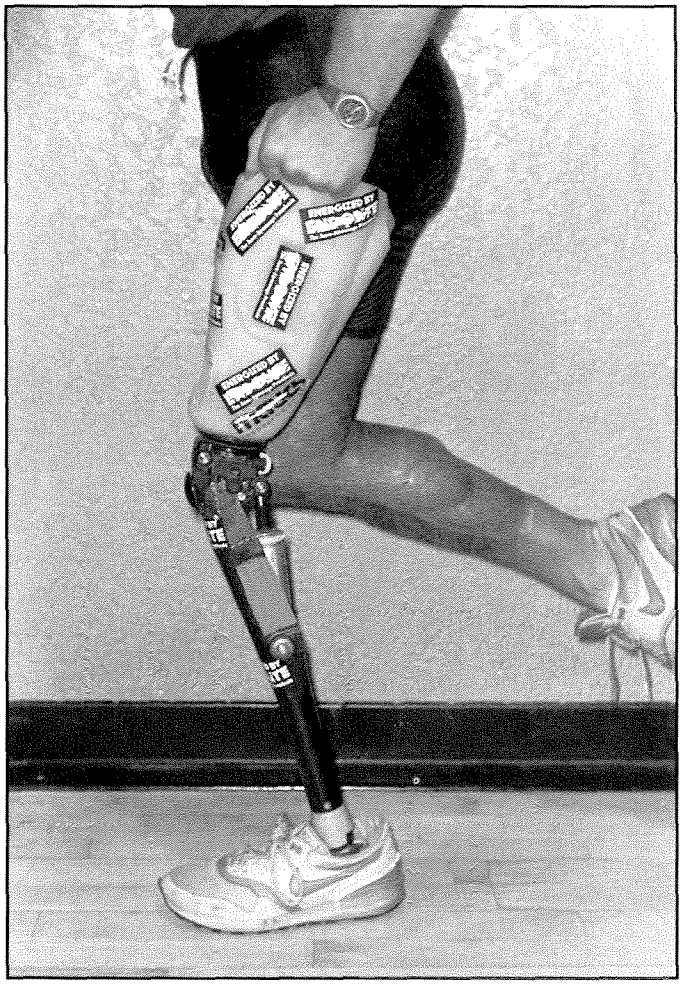
DALE TILLY/VAMC, SEATTLE, WA
Front view of the CAT/CAM Flexible Brim socket. A polypropylene retainer socket is connected to the Endolite Stabilized StanceFlex (Bouncy) Knee unit.

the quadrilateral socket. This reduces shock forces on the ischial tuberosity at heel-strike, which is particularly important since running produces ground reaction forces that amount to three to five times the body weight.[11] A conventional prosthesis with quadrilateral socket design will not allow the individual to withstand forces so great while running.

A socket with ischial containment also provides alignment stability and control of the femur that surpasses that of the quadrilateral socket. There are several names for sockets based on these principles of design: the Narrow M/L or Normal Shape Normal Alignment (NSNA) socket, the CAT/CAM socket, and the Ischial Ramal Containment (IRC) socket, as well as several derivatives.

Hydraulic knees that feature stance and swing control, such as the Mauch SNS Knee Unit, provide the stability and knee flexion control at midstance needed by AK runners. The Mauch SNS Knee Unit is excellent for running when enhanced with the Endolite Stabilized StanceFlex (Bouncy) Knee. When these two units are combined, they provide a form of cushioning from the rubber torsional element. This reduces the forces on the residual limb and results in increased comfort, adding to the forward propulsion of the limb during the later stages of the stance phase.[12]

There is also a need to accelerate the lower shank portion of the leg fast enough to get it out in front of the runner. A device designed for foot-over-foot running, the OKC Running System, does this. The system extends the lower portion of the leg



DALE TILLY/VAMC, SEATTLE, WA

The Endolite Stabilized StanceFlex (Bouncy) Knee supports weight at mid-stance for runners with single-limb soundness. Also shown is a flexible brim CAT/CAM suction socket and a Mauch Swing Phase Hydraulik Knee Unit, which is used for cadence control while running.

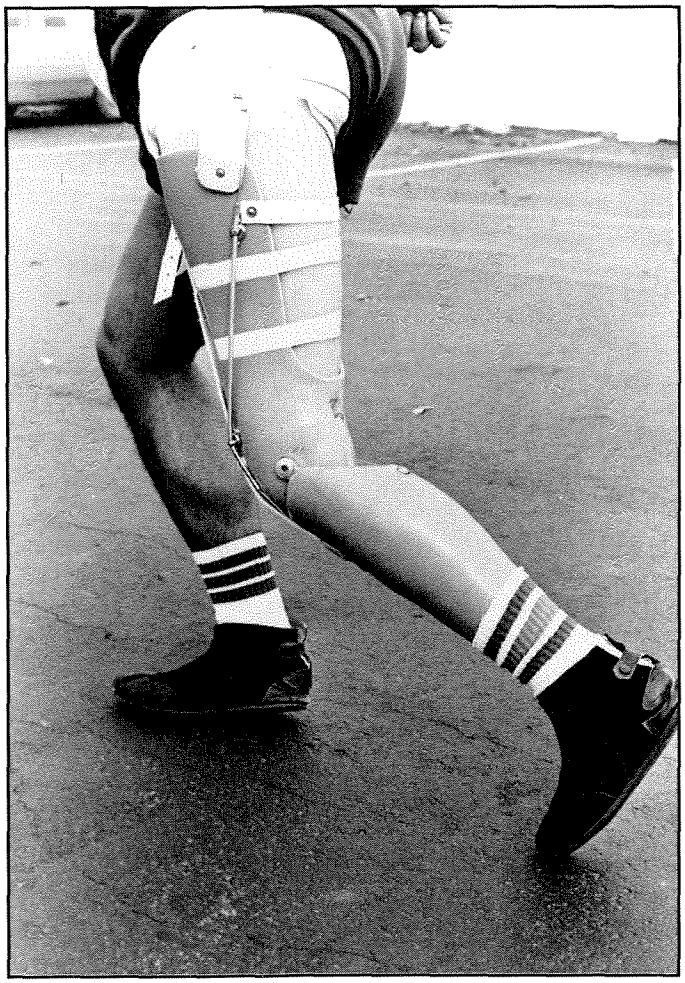
DALE TILLY/VAMC, SEATTLE, WA

The Endolite Stabilized StanceFlex (Bouncy) Knee is attached between the above-knee socket and the knee unit. The rubber torsional element provides impact cushioning while running.

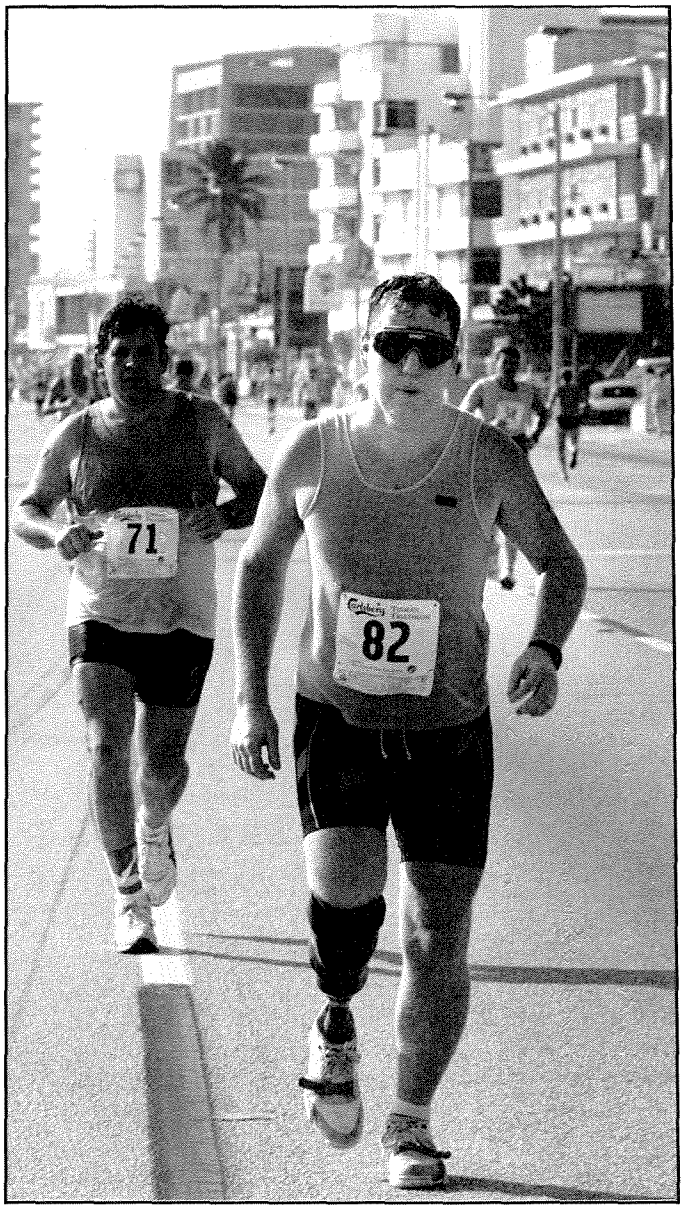
quickly enough to maintain the rhythm of foot-over-foot running. The system allows for hip flexion while tension is drawn on a cable which attaches to and extends the lower shank section of the AK prosthesis. When the lower portion of the leg is not extended quickly enough, a hop-skip pattern will allow the prosthetic leg to "catch up."[13] A constant friction knee can be used with the OKC Running System, acting as a stabilizer during the stance phase because it keeps the leg extended until toe off.

The OKC Running System is excellent for teaching people with AK amputation to run because the cable does the work for them and they can have immediate success. If desired, the system can be removed from the leg when the user learns how to run. However, many users prefer to keep it attached to the leg because it insures placement of the leg in front of them when running.

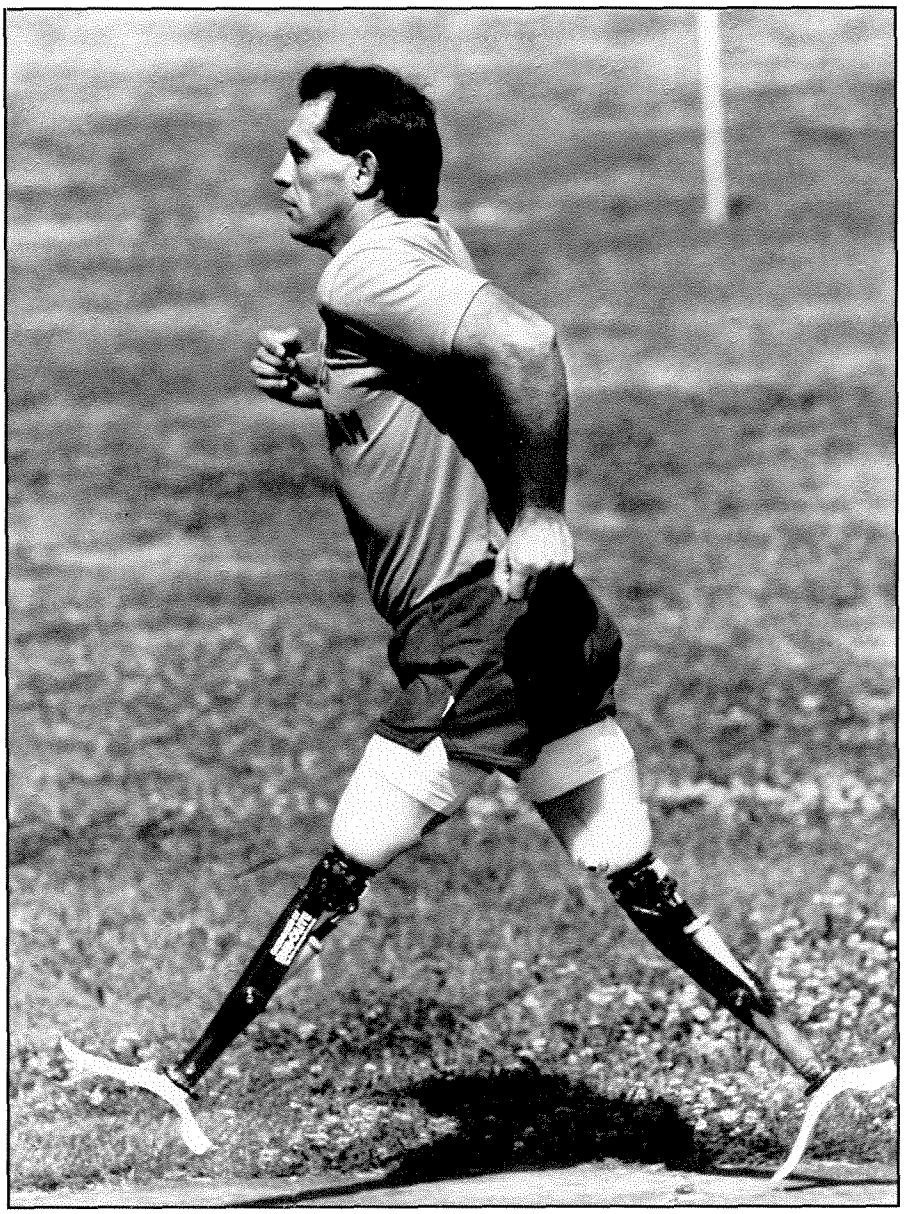
Flexible sockets, stance-controlled knees, and energy-storing feet, combined with training and practice, now enable people with AK amputation to run if they wish. However, running foot-over-foot is most common for shorter distances and limited time periods. The majority of runners still run long distances using the hop-skip step method. To date, there has not been a runner with AK amputation who has completed an ultra-marathon or cross-country event running foot-over-foot. However, it is undoubtedly only a matter of time.



SABOLICH P&O CENTER, OKLAHOMA CITY, OK
The OKC Running Cable is attached to an exoskeletal prosthesis with a flexible brim CAT/CAM socket, constant friction knee, and SAFE Foot. This system allows for foot-over-foot running.



NEWS/SUN-SENTINEL, FT. LAUDERDALE, FL
After swimming 1 mile and cycling 25 miles, Richard Hughes runs 10 kilometers to finish a triathalon.



SABOLICH P&O CENTER, OKLAHOMA CITY, OK

Roger Charter, thought to be the first person with bilateral above-knee amputation to run foot-over-foot, is shown running with the energy-storing Sabolich Feet and CustomFlex Sockets™.

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16

AEROBIC DANCE

Over the past decade, aerobic dance classes have become one of the most popular activities at health clubs and community centers throughout the country. For many people, the term "aerobics" has become synonymous with this form of dance and coordinated exercise set to music.

A typical aerobic dance class begins with a slow warm-up period, then progresses to a level of activity that should maintain a targeted heart rate for a minimum of 20 minutes. A general cool-down period follows. Cardiovascular conditioning, muscle toning, and stretching are emphasized through coordinated dance steps and body movements. Aerobic dance classes are fun: people jump, kick, and sometimes yell or sing, all to the beat of lively music.

The intensity of this activity should not discourage a person with lower limb amputation. Because aerobic dance is so popular, classes for a wide range of skill levels are available at most clubs and community centers. "Low-impact" classes are the least strenuous with regard to jumps and kicks; thus, there is less danger of excess pressure on the residual limb.

For people over the age of 60, those with high level bilateral amputations, or those just learning to function with a prosthesis, it may be best to choose a class in which the participants are seated. Seated classes do not provide the same degree of aerobic strengthening; nonetheless, they can effectively provide some cardiovascular conditioning through routines that exercise the upper body, shoulders, arms, and legs to a limited degree.

PREPARING FOR AEROBIC DANCE EXERCISE

Many aerobic centers have installed special floors that have a rebound action to cushion the impact effect on the body. The person with lower limb amputation should choose a class in a facility with this type of floor if possible, and begin with low-impact exercises that do not require jumping movements.

Aerobic dance shoes are specially designed to soften the impact to the body and to stabilize the foot. Impact-absorbing insoles, such as those available from Spenco, can be placed in aerobic dance shoes (or in any other tennis or training shoe) to further reduce the impact on the residual as well as on the sound limb. However, adding insoles to shoes can cause changes to the alignment of the prosthesis. When dance shoes are worn with insoles, a prosthetist should check their prosthetic alignment before they are used for exercise.

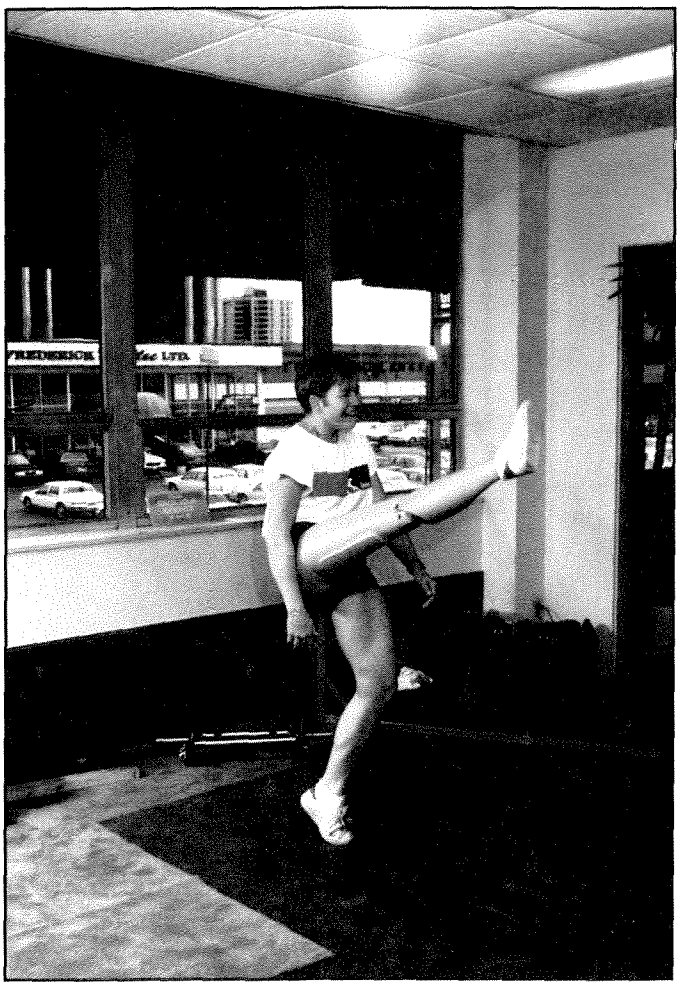
In order for the lower limb amputee to get the full benefit of aerobic exercise classes, the prosthesis must allow for stability and range of motion. Certain range-of-motion exercises may not be possible, depending upon the design of the prosthesis. In some cases, the limitations can be minimized by making special adaptations to the prosthesis, as discussed later in this chapter.

With a good-fitting prosthesis and conscientious practice, a person can often work up to "high impact" aerobic dancing. One can modify the pace and technique of the dance routine in a way that still

achieves a good aerobic workout. For example, one could jump on the sound limb only, or jump every other time on the prosthesis rather than every time, as the routine may require. The dance routines are going to be more difficult for an individual with bilateral amputation—in those cases, low-impact aerobics is advised.

For those with partial foot loss, jumping up and down places multiple stresses on the residual foot. In such cases, it is important that the prosthetist adjust the fit of the shoe insert of the prosthesis so that the exercises do not cause pain or create blisters on the residual foot. High-top aerobic shoes are recommended because they provide additional ankle support. Again, it is best to begin with low-impact exercises.

The person with a hip disarticulation amputation is unlikely to participate in aerobic dancing while wearing a prosthesis. It is usually easier to participate without the prosthetic limb. However, the sound leg must be protected. A program that involves jumping as the main form of exercise, as in high-impact aerobics, should be avoided. Low-impact or seated aerobic classes, or water aerobics, are the better choices.



PROSTHESES AND SPECIAL DEVICES

Energy-Storing Feet

The Seattle Foot, Flex-Foot, Springlite Foot, Carbon Copy II Foot, Quantum Foot, SAFE Foot, DAS Foot, and STEN Foot help reduce the impact that results from jumping up and down. The Terry Fox AK Spring Device can be adapted to reduce vertical shock loads when jumping. (This device is still experimental and not commercially available). The Carbon Copy II Foot, the SAFE Foot, and the new Seattle Lite Foot are energy-storing feet that accommodate Syme's amputation during jumping activities. The Springlite Foot for Syme's is now available on a limited basis.

Below-Knee Adaptations

Socket Interface. Total surface-bearing sockets that evenly disperse vertical force loads on the residual limb are best suited for high-level activities such as aerobic dance exercises. Liners that have impact-absorbing qualities include silicone liners that absorb the shear forces on the residual limb, multiple durometer liners that use a combination of materials, and the PM liner.

Flexibility. Range of motion and flexion of the knee are important in order to perform many aerobic exercises. The prosthetist may be able to modify the trim lines on the condyles or hamstring areas of the prosthesis. If modifying these trim lines creates functional problems when the prosthesis is used for walking, flexible "ears" or brims can be made out of flexible resins or thermoplastics. For the avid exerciser, a special leg can be used specifically for aerobics.

Suspension. Good prosthetic suspension is necessary to prevent blisters. Suspension sleeves control pistoning and allow for full extension of the knee. However, they do have some disadvantages. Latex and neoprene suspension sleeves may restrict flexion

of the knee and may feel hot while exercising. A cuff suspension with an additional waist belt attached will limit full extension of the knee in certain cases. One way to solve these problems and improve suspension is to wear a neoprene suspension sleeve over a cuff strap suspension.

A Silicone Suction Socket (3S) or Icelandic Roll-on Suction Socket (ICEROSS) can also be effective in eliminating the need for straps, sleeves, and in some cases, stump socks. The Hyperbaric Socket utilizes a silicone that is band-impregnated to the sock, creating a suction BK socket and eliminating the need for belts, straps, or sleeves.

Above-Knee Applications

Those with amputations above the knee will benefit from a stable Stance Phase Knee unit, a flexible socket, and an energy-storing foot.

Knee Units. The "Bouncy Knee" can be added to an Endolite Knee Unit to reduce the impact on the residual limb, absorb shock, and provide cushioning from the rubber torsional element. Another option is to use the Mauch SNS Knee Unit, which is helpful if one is jumping while wearing a single, prosthetic limb. This device also provides stability for maintaining balance.

Socket Interface/Suspension. The CAT/CAM or Narrow ML socket can reduce the vertical loading of the prosthesis, as compared with the standard quadrilateral socket. The Narrow ML socket reduces the pressure against the ischial tuberosity by fitting inside the socket, and offers increased alignment stability. The conventional quadrilateral socket does not adequately provide this protection; the ischial tuberosity rests on the posterior shelf and may be uncomfortable during the wearer's performance of aerobic exercises. When worn for such activities, it is best to alternate and modify the aerobic routine by jumping on one leg at a time or by jumping every other sequence.

Flexibility. Certain range of motion exercises may be impossible or quite difficult, depending upon the design of the proximal brim of the prosthesis. A flexible brim socket design will work best for extensive range-of-motion exercises, particularly when the wearer bends forward to touch the floor and the hip is flexed. The ISNY-style socket allows the inner socket to expand for muscular activity and many people feel there is less heat build-up than with other sockets. Above-knee suction sockets that have adequate suspension for walking may need the additional suspension of a Silesian Belt or TES Belt when used for aerobic dance, especially when the inside of the socket becomes moist, making it more prone to slippage.

SPECIAL CARE

People who have lost a limb usually perspire more than people who have their extremities intact. The body's heat is dissipated at a higher rate through the limited skin surface area. Because the socket of the prosthesis is not porous, skin areas covered by the prosthesis can experience excessive perspiration during physical activity. Also, because an artificial limb is less efficient than a sound limb, a participant will put forth more energy and therefore will perspire more when exercising.

Stump socks should be changed before and after aerobic exercise because heat generated within the socket may cause skin irritations. An additional-ply stump sock can be used during exercise. Many people experiment with sock combinations if their usual stump sock is not adequate for aerobics. Certain BK residual limbs may benefit from having the shear forces reduced by the use of a silicone gel liner. Sheaths should also be worn under the stump socks to reduce and wick away the perspiration on the skin surface. The Drionic Sweat Control device can help when residual limb perspiration is complicated by skin problems.

To help prevent blisters, Spenco™ Skin Care Pads, Spenco™ 2nd Skin™ or Johnson & Johnson Bioclusive® Pads should be applied to potentially problematic areas of the stump before each exercise class. If a blister does develop, these skin care pads also aid healing and reduce pain while walking. It is important to know when to stop exercising. The exerciser should not continue if the pain is such that the prosthesis can not be worn.

Clothing worn during exercise should allow heat to dissipate quickly. Loose-fitting, lightweight cotton clothing is better than sweatshirts and sweatpants. Initially, some people may feel uncomfortable wearing shorts in public. Long pants are fine as long as they are loose-fitting and are of lightweight cotton.

WATER AEROBICS

Exercises that are difficult or impossible for a person with lower limb amputation become effortless and enjoyable when performed in water. Water aerobics is an excellent and gentle method for conditioning the entire body and is nontraumatizing to the residual limb.

The popularity of water aerobics has grown considerably over the past few years; it is now taught in many health clubs and in other facilities with swimming pools. Like swimming, it is very relaxing and effective in reducing tension and the risk of injury.

"Many doctors and therapists recommend water aerobics for patients who are unable or unwilling to participate in other forms of exercise," says Barbara Schaut, a water aerobics instructor in Seattle, Washington. According to Mrs. Schaut, water aerobics has a special advantage over floor aerobics for those with lower limb loss because the person is no longer handicapped when in the pool. "The warmth of the water loosens and relaxes muscles while the support and cushioning effect allows greater range of joint motion. In addition, water creates a resistance against the body producing a therapeutic and strengthening effect on muscles and joints."

Because extra force is required to move through water, the movements are slower and less physically stressful. The body, supported by water, becomes buoyant, making possible the execution of exercises often unachievable outside of the pool, allowing the participant to move freely without harmful results.

The exercises can be performed with or without a prosthesis, although people with bilateral amputation would need to wear their prostheses in order to stand on the bottom of the pool. (Water aerobics require use of the arms to create resistance in the water. The bilateral amputee not wearing a prosthesis would just be treading water.)

Care of the skin is important, particularly in a highly chlorinated pool. Water tends to deplete the natural oils in the skin. In some cases, chemicals in the water may cause the skin to become very dry and irritated. The residual limb should be cleaned with mild soap and water immediately after the workout. Badly dried-out skin can benefit from Vite 28-32000 I.V. applied directly to the skin when the prosthesis is removed at night. Routine skin care is essential to prevent postworkout problems and to minimize the breakdown of healthy skin, particularly on the residual limb. A physician should be consulted if the skin becomes badly dried out.

17

SWIMMING

Swimming is one of the best forms of physical conditioning. It strengthens the cardiovascular system and involves the major muscle groups of both the upper and lower body. It also develops flexibility and strength in the muscles and joints as the swimmer performs a wide range of motion against the water's resistance. Since the body and limbs are rhythmically stretched in swimming, it is possible to warm-up and cool-down in the water by doing slow and simple strokes.

An important consideration for a person with an amputation is that swimming is not traumatic to the residual limb. The water's buoyancy evenly distributes and supports the weight of the body; there is no danger of falling, and there are no impact forces on the residual limb.

Many recreation centers offer instructional programs for people with physical disabilities. Nonswimmers should consider joining a special swim instruction program that includes techniques for entering and leaving the pool. Even someone who was a good swimmer before lower limb loss may need to modify some techniques such as a kick-turn at the wall (some swimmers may need to use their hands as well as their feet).

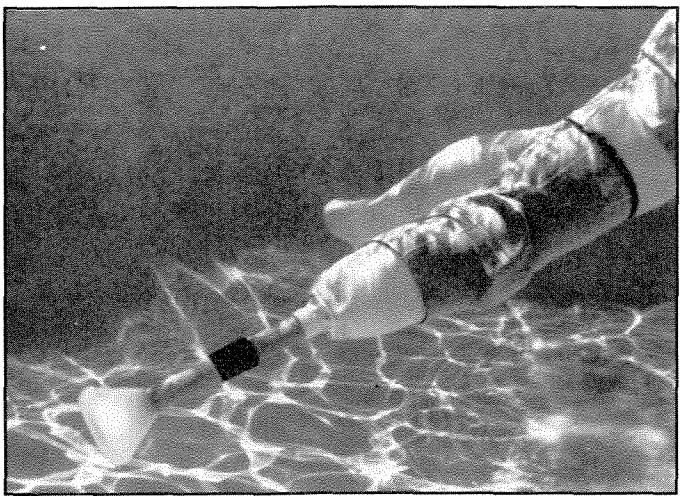
GETTING IN AND OUT OF THE WATER

Most problems connected with swimming are associated with getting in and out of the pool, lake, or ocean. Pool areas are wet and slippery; rocks and shells found at the beaches can be dangerous. Hopping to and from the water is not safe, and the use of a swim prosthesis, peg leg, or crutches is always recommended.

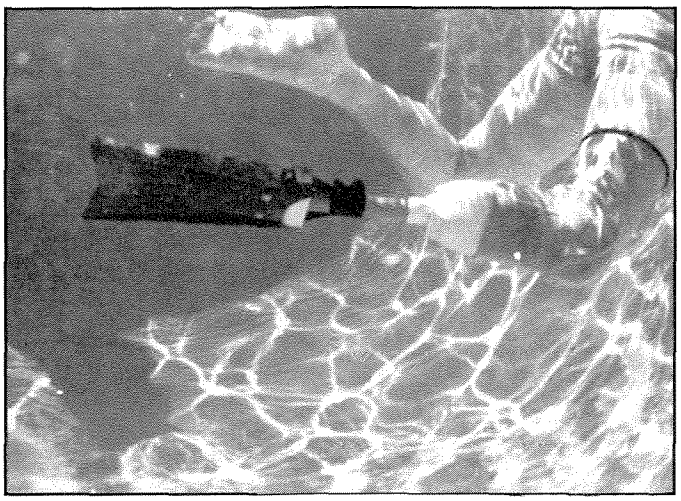
Those who choose not to use a prosthesis while swimming can remove it and leave it near the water's edge or poolside near the ladder (at a public pool the prosthesis should be covered with a towel so that its presence does not offend anyone). However, the prosthesis should not be left in areas where others are entering and leaving the pool (e.g., near steps or diving boards). If the prosthesis is not waterproof, the swimmer may prefer to leave it in the locker room and enter the pool area using crutches. Crutches should be left by the poolside so they are accessible when the swimmer gets out of the water.

Swimmers without a prosthesis can enter the pool using built-in stairs, a special swimming lift, or by simply jumping or diving into the water. If necessary, built-in stairs can be negotiated by sitting on the steps and using the hands to move the body into or out of the water. If the prosthesis is not left by the poolside, some individuals may require assistance in lifting themselves out of the water. If needed, a wheelchair can be used to get a swimmer to the pool and a hoist can be used to lower him/her into the water.

Swimming alone in a pool is a pleasure for a competent swimmer, but in an ocean or lake it is not recommended for anyone. Swimmers will find it wise to have a swimming partner or an observer in



RICHARD SIMS, SEATTLE, WA
A swim prosthesis made of a supracondylar BK socket with neoprene suspension sleeve and Orthomedics Pylon/Peg.

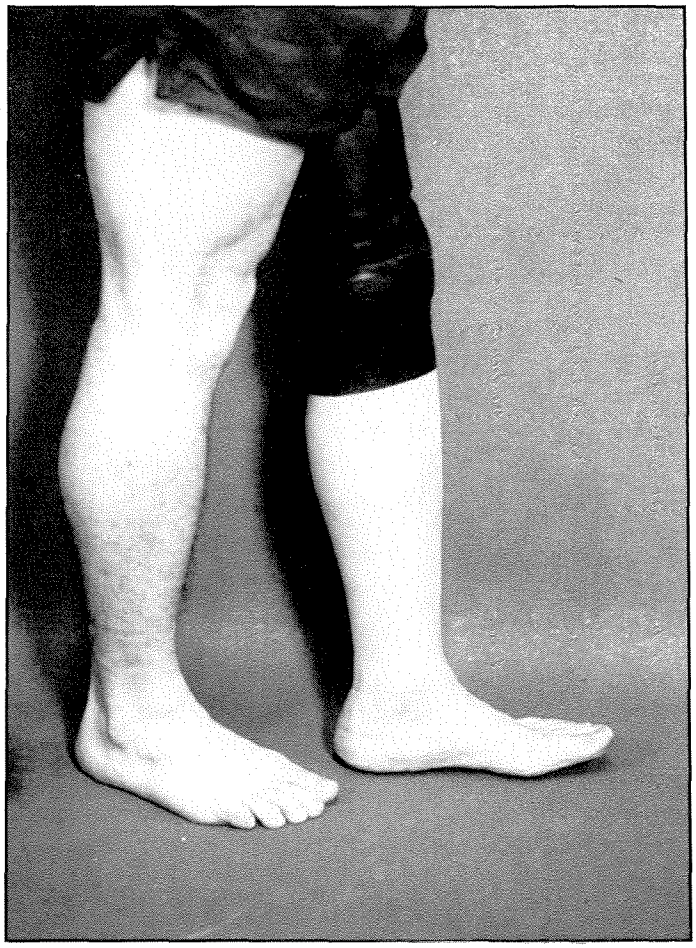


RICHARD SIMS, SEATTLE, WA
A flipper is attached to the prosthesis for increased underwater swimming propulsion. This leg also provides for easy movement into and out of the water.

case a problem develops and immediate assistance is needed. A strong current, fatigue, or other unforeseen circumstances may make it necessary to return to the shore. If the swimmer is some distance away from where the prosthesis or crutches were left, it could be difficult to hop or crawl to reach them. Wearing a swim prosthesis avoids the problem of entering and leaving the water in two different places.

ADAPTIVE TECHNIQUES

Although a person can certainly enjoy swimming without the use of a prosthesis, there are definite advantages in wearing one. A waterproof or swim prosthesis provides balance in the water through even weight distribution. Without a prosthesis, a swimmer with unilateral amputation may find that the body tends to pull or drift to the side of the sound leg. Swimming within the lanes of a pool or sighting certain markers in open water will help in keeping on a straight line when swimming without a prosthesis.



SHIRLEY FORSGREN/PROSTHETICS RESEARCH STUDY, SEATTLE, WA
Exoskeletal BK prosthesis with Seattle Foot used for everyday walking, sports, etc. When the ActivSleeve is used and New Skin is applied, the prosthesis may double as a waterproof leg for swimming. Because of its rigid foam base, the leg is buoyant but can be used for swimming in a pool. When diving, a weight belt is needed to compensate for the buoyancy.

DREW HITTENBERGER, CP/PROSTHETICS RESEARCH STUDY, SEATTLE, WA

Bilateral BK prostheses with polypropylene sockets, adjustable PVC pylons, and waterproof SAFE feet. Michigan Suspension Sleeves are used to prevent water from entering the socket and provide good suspension. (For more information, *see* D. Hittenberger: A Thermoplastic Endoskeletal Prosthesis. *Orthotics and Prosthetics,* 37(2), 45-52, 1983.)

A prosthesis will also add power to the swimming strokes. For example, when using a kickboard without a prosthesis, there may be no problem kicking, but the swimmer will remain in place. Without the power of both legs, it may be necessary to use the arms in order to proceed.

Doing kick-turns to push off from the pool wall is the same with a prosthetic swim leg as for any two-legged swimmer. For increased speed, it is to the advantage of the swimmer to master the kick-turn. However, those who swim without a swim leg need to compensate for loss of power by developing their own techniques to push off from the pool wall with only one foot. If turning over is a problem, a swimmer can use both hands to touch the wall and push off with one leg. A swimmer with a bilateral amputation can simply touch the wall with one hand and then push off the wall with one or both hands.

SWIM PROSTHESES

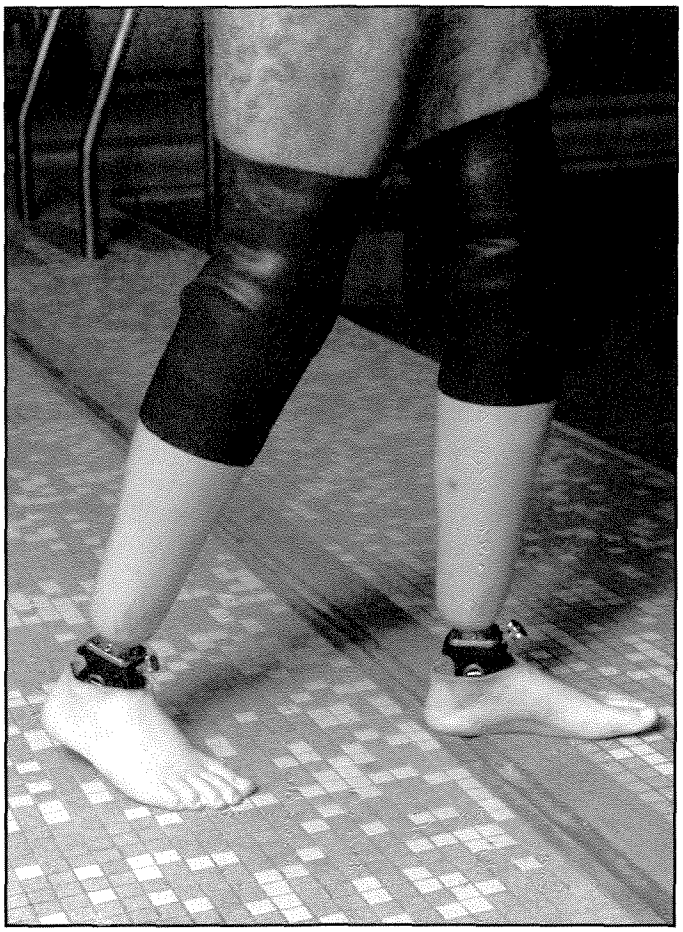
If swimming is to be a regular activity, a waterproof prosthesis or a special swim leg is a worthwhile investment. For those with bilateral amputations, a swimming prosthesis helps to get in and out of the water. A prosthesis with a fin attached adds power to the kicking motion, strengthening the muscles in the residual limb.

There are many types of swim legs, including the waterproofed everyday walking leg, peg leg, stubbies, and the hollow-chambered leg that compensates for buoyancy. Buoyancy control is important for underwater swimming and for skin or scuba diving. If a non-hollowed leg is used, buoyancy can be controlled by adding a weight belt and using a buoyancy-compensation vest. Swim/walk legs and ankles also can be designed to be held in an extended plantar-flexed position for use with fins. Individualized combinations can be made as well.

Below-Knee Adaptations

Waterproof prostheses for people with BK amputations can be made from a regular walking leg treated with New Skin. A cuff suspension made of leather, Dacron™, or cotton straps will not work well for swimming because these materials are not waterproof. A plastic, waterproof version is available from Otto Bock® Orthopedic Industry Inc., but it will not keep water from entering the socket. Use of a rubber suspension sleeve like the ActivSleeve, Michigan Sleeve, or Otto Bock Swimming Sleeve will keep water from entering the socket, protect the liner, and keep stump socks dry. After leaving the water, walking with wet stump socks can cause blisters. Therefore, keeping the inner socket and residual limb dry is very important in preventing skin breakdown and blisters.

Hard sockets are preferable, because they are easy to clean and dry. If liners are used, they should be made from a fast-drying, nonporous material. A



SUSAN BROWN/VAMC, SAN DIEGO, CA
Hollow-chambered exoskeletal BK swim prostheses. The ActivAnkle can place the foot in a position for walking (90 degrees) or flex to accommodate swim fins (160-180 degrees). ActivSleeve suspension helps to prevent water from entering the sockets. Carbon Copy II Syme's feet are used along with Otto Bock Titanium Rotatable Socket Adapters on the hollow-chambered legs to compensate for buoyancy.

SUSAN BROWN/VAMC, SAN DIEGO, CA
The hollow-chambered exoskeletal prosthesis fills with water to compensate for buoyancy while swimming or diving. Out of the water, the leg is drained as shown. An additional airhole on the posterior proximal portion of the legs allows water to drain (and fill) more quickly.

spare liner should be available for use while the other is drying. A hair dryer will dry a wet liner quickly (care must be taken not to distort the liner by overheating).

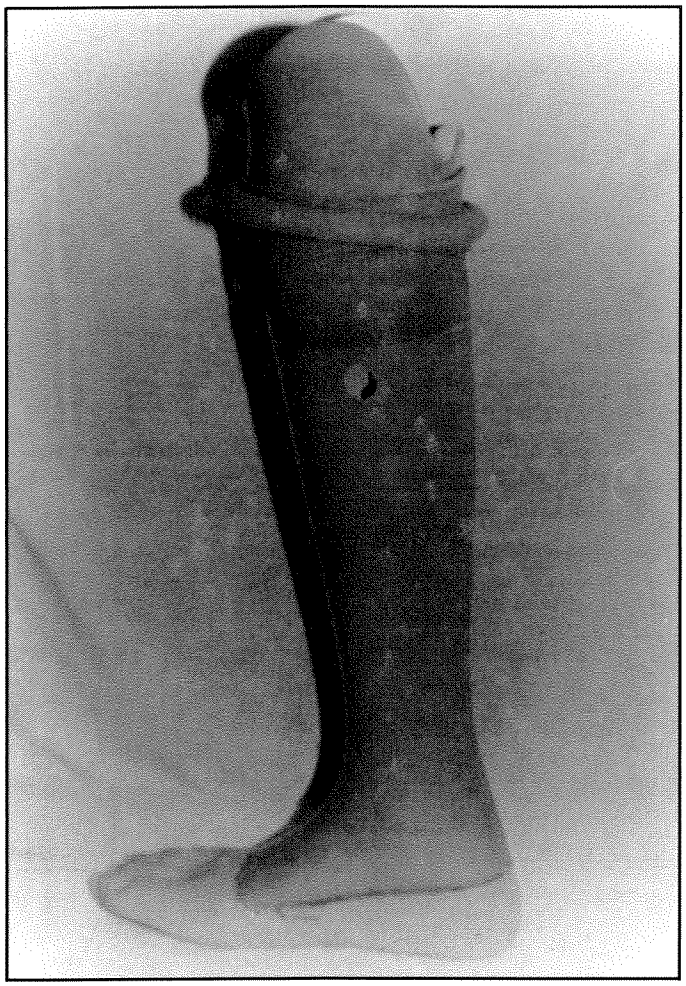
Above-Knee Adaptations

Swimmers with AK amputations can use straight exoskeletal prostheses without a knee or use a peg leg. The 3K9 or 3K5 Otto Bock leg, which locks the knee in extension for walking in the water and bends while seated, is an excellent swim prosthesis. It is water resistant and has a plastic knee. The shank can be hollowed out, as can the area below the socket, to make the prosthesis lightweight in the water. The hollow shank will allow water to fill up inside, controlling buoyancy, and will drain when the swimmer leaves the water. The leg comes apart at the knee for easy storage.

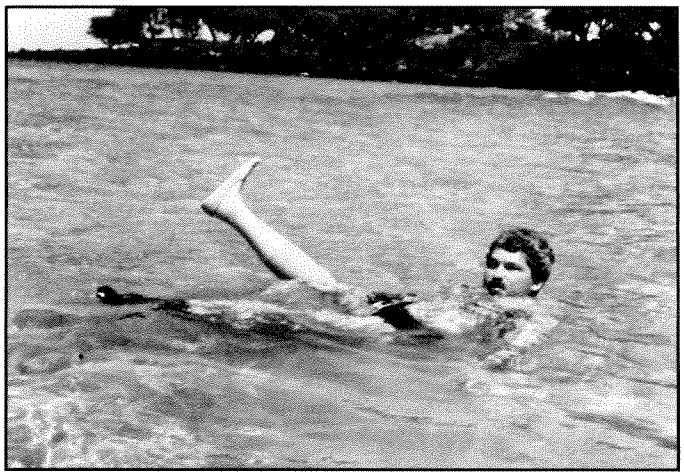
Above-knee suction suspension can be enhanced with a plastic hip-belt from Otto Bock or a TES belt made of neoprene. The suction suspension is usually adequate for everyday activities, but when swimming, adding a belt will assure that the limb will stay in place.

PROSTHETIC FOOT ADAPTATIONS

Regardless of the level of amputation, the type of foot used in a swim prosthesis is important.



JOE ZETTL, CP/AMERICAN ARTIFICIAL LIMB CO., SEATTLE, WA
Lightweight exoskeletal BK prosthesis with waterproof Beachcomber Foot (Kingsley Manfacturing) and fixed ankle. The Michigan Sleeve is used for suspension. The prosthesis is hollowed out for water entry, to compensate for buoyancy. Water drains out of an opening on the bottom of the foot.



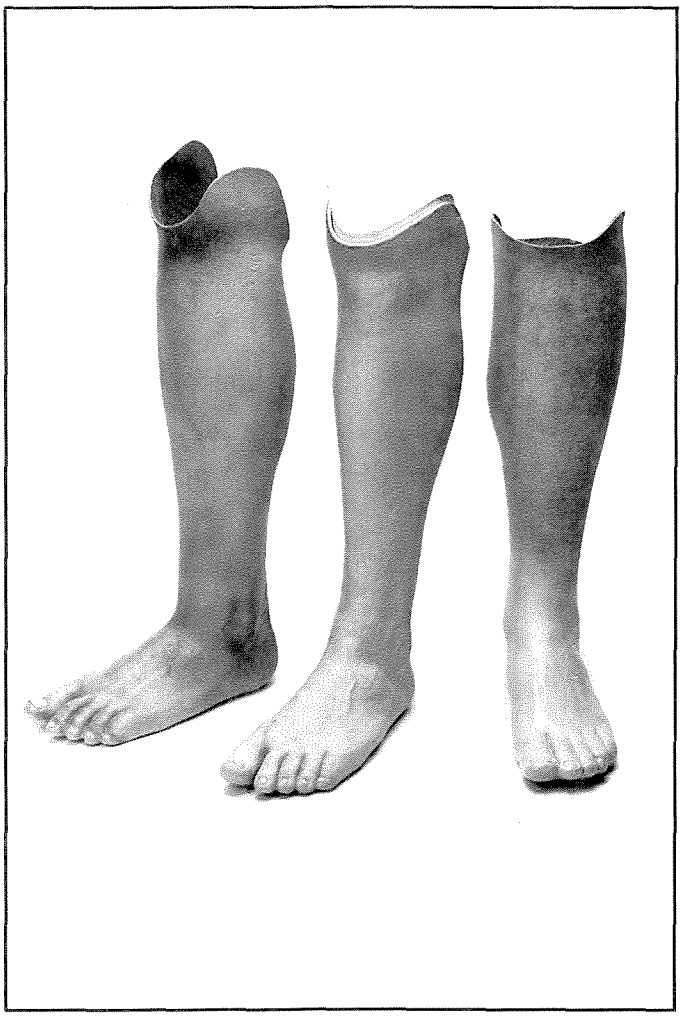
JOE ZETTL, CP/AMERICAN ARTIFICIAL LIMB CO., SEATTLE, WA
A swimmer wearing the hollow exoskeletal prosthesis and waterproof Beachcomber Foot.

JUDD LUNDT/UCLA PROSTHETICS EDUCATION PROGRAM, LOS ANGELES, CA
A swimmer with bilateral AK amputation is wearing stubbies with fins attached and prepares to enter the water.

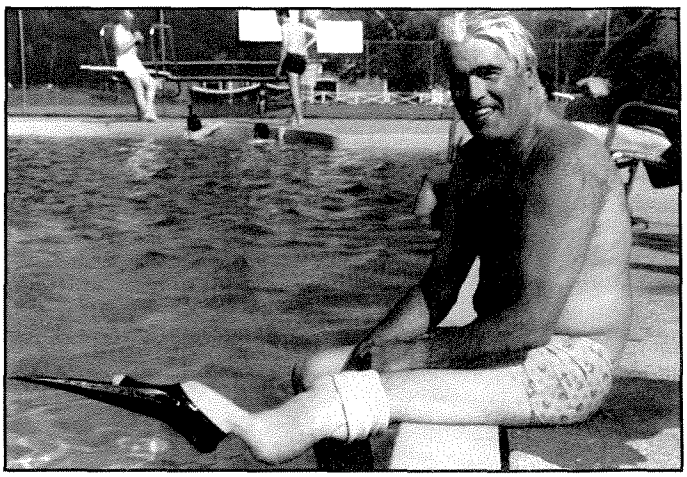
Certain styles of the SACH Foot, Seattle Foot, SAFE Foot, and Dynamic Foot are best in the water. These feet are molded without an external heel cushion, making them less susceptible to becoming water-logged. Feet with external foam cushion heels and many standard SACH Feet, however, will absorb water like a sponge.

Any foot used for swimming should be treated with New Skin or waterproof foot paint, like that available from Otto Bock, Skoat Coat from DAW, or Ultradip. This is also true for any endoskeletal foot that has a soft foam cover, such as Endolite or Quantum. (Flex-Foot uses a special E.V.A. foam that is water resistant.) If the foot is untreated, water will penetrate the foam and eventually cause it to break down prematurely. The foot coatings can be used to waterproof the entire prosthesis.

The ankle and its foot bolt should also be waterproofed to guard against rust. If just the foot and ankle need to be waterproofed, an elastic bootie (available from Otto Bock for adults; a foot cover for children is available from Realistic) can be used over the foot instead of coated treatments. However, the bottom of these booties can tear when walking barefoot on hardened surfaces. If this is a problem, a coating of New Skin or other product



JOHN WOODMANSEE/VAMC, SEATTLE, WA
Waterproof/cosmetic BK prostheses for everyday and water use. From left in the photo: Graphite socket on exoskeletal prosthesis and Seattle Foot (cosmetic treatment: Peyton Massey, Jr., New Life Labs); UCLA CAT/CAM socket with Pelite liner, Seattle Foot and Ankle (cosmetic treatment: Glen Campbell Cosmetic Prosthetics); Ultralight Graphite/Epoxy socket, Teh Lin Graphite pylon and pylon connector, Carbon Copy Foot (cosmetic treatment: Dan Tatum, Cascade Orthopedics). All three legs are treated with New Skin and are waterproof; they were constructed by Albert Rappoport, C.P.



CHAMP MAGAZINE
A swimmer wears the Flipper/Foot with the fin attached to his BK socket.

should be used. These methods are more durable and attractive.

Stubbies for AK swimmers may also be used for walking as well as for entering and leaving the water. A swimmer can use a UCLA CAT/CAM/Narrow ML Flexible Suction Socket, which is an interchangable socket that will fit into a walking leg.

The Kingsley Beachcomber Foot is the only foot that was originally designed for use in the water. It is also flat-bottomed for barefoot walking. Other types of feet, such as the Otto Bock Foot or the SACH Foot, may be converted to a flat-bottomed barefoot walking position for swimming. This is done by adding a pedilon arch filler treated with a waterproof covering. Many amputees can learn to walk short distances barefoot even without having a fully flat-bottomed heel.

SWIM LEG GUIDE

PEG LEG USED FOR BK OR AK AMPUTATION
- Whomper Stomper, Atlantic Prosthetics
- Orthomedics peg leg
- PVC Pipe with rubber bottom
- Aqualite, USMC

PEG LEG WITH FIN ATTACHED FOR BK OR AK AMPUTATION

SWIM ANKLE FOR FIN USED FOR BK OR AK AMPUTATION*
- VAPC Swim/Walk Ankle
- ActivAnkle

LATEX RUBBER SLEEVE USED ONLY FOR BK AMPUTATION*
- ActivSleeve (various distributors)
- Michigan Sleeve
- Otto Bock Swimming Sleeve (Otto Bock Industries, Inc.)

HOLLOW-CHAMBERED LEG FOR BK OR AK AMPUTATION*†
- Otto Bock Hollow Ultra Light (Otto Bock Industries, Inc.)
- Walt Beneke, Ultra Light, BK (Graphite) (Graphite Prosthesis Manual available from Bee Supply, Reno, NV)

FLAT FOOT FOR BAREFOOT WALKING FOR BK OR AK AMPUTATION
- Beachcomber Foot (Kingsley Mfg.)
- Arch Filler, 2F15 (Otto Bock Industries, Inc.)
- Adjustable Heel Height SAFE Foot (Campbell Childs, Inc.)

WATERPROOF WALKING LEG FOR BK OR AK AMPUTATION
- New Skin (New Skin Labs)
- Elastic Bootie (Foot Cover)
- Otto Bock or Realistic Labs
- Skoat Coat (Daw, Inc.)
- Ultradip

CUFF SUSPENSION FOR BK AMPUTATION
- Otto Bock, Plastic Cuff, 21B16 (Otto Bock Industries, Inc.)

SOLID ONE PIECE EXOSKELETAL WATERPROOFED LEG (NO KNEE) FOR AK AMPUTATION†
- Otto Bock waterproof 3K-9 or 3K-5 (Otto Bock Industries, Inc.)

EXOSKELETAL LEG WITH KNEE LOCK FOR AK AMPUTATION*
- Otto Bock waterproof 3K-9 or 3K-5 (Otto Bock Industries, Inc.)

WATERPROOF SUSPENSION BELT FOR AK AMPUTATION*
- Otto Bock plastic suspension belt 21B17 (Otto Bock Industries)
- TES belt (Neoprene)

STUBBIES WITH AND WITHOUT FINS FOR AK AMPUTATION*†

*Necessary for skin or scuba diving.
†Not a stock item. Must be custom fabricated by your prosthetic facility.
Note: Any of the above types may be combined and custom fabricated.

18

CYCLING

The first "two-wheeler" is a big event in a child's life and often signifies a new degree of independence and wider boundaries of exploration. Many adults will remember the occasion and the bike fondly. They will be able to recall its color and make and describe their adventures learning to balance themselves and ride. It is true that once you learn how to ride a bike you will never forget, although you may become a bit "rusty."

Bike riding or stationary bike exercise is often one of the most readily adaptable methods of aerobic conditioning. Stationary bicycles can be adapted to most individual physical capabilities and bikers can ride with or without a prosthesis. Bikers can ride outdoors, use a stationary bike indoors, or combine both modes in their conditioning program. Minor adjustments and/or adaptations to the prosthesis and bicycle are often needed; they are best determined individually through practice and experience.

Most people with lower limb amputation can receive much pleasure and physical benefit from cycling, with little risk of injury. Cycling places very little stress on the residual limb. It is essentially a non-weightbearing activity because the rider is seated most of the time. At the same time, it is one of the best ways to strengthen the quadriceps and hamstring muscles of the thigh as well as muscles of the hips. Besides training the cardiovascular system and building muscular endurance, cycling is an excellent method for strengthening the residual limb.

Individuals with BK amputations may find it to their advantage to use their prosthesis while biking. Some people with an AK amputation and most with hip disarticulation may choose to ride without a prosthesis. For the rider with AK amputation, pedaling can cause socket impingement when flexing the hip. This can be remedied by the prosthetist in many cases. Those with hip disarticulation experience difficulty riding with a prosthesis, because the limb cannot be effective for pedaling without muscular control of the natural hip and knee joints.

TRAINING

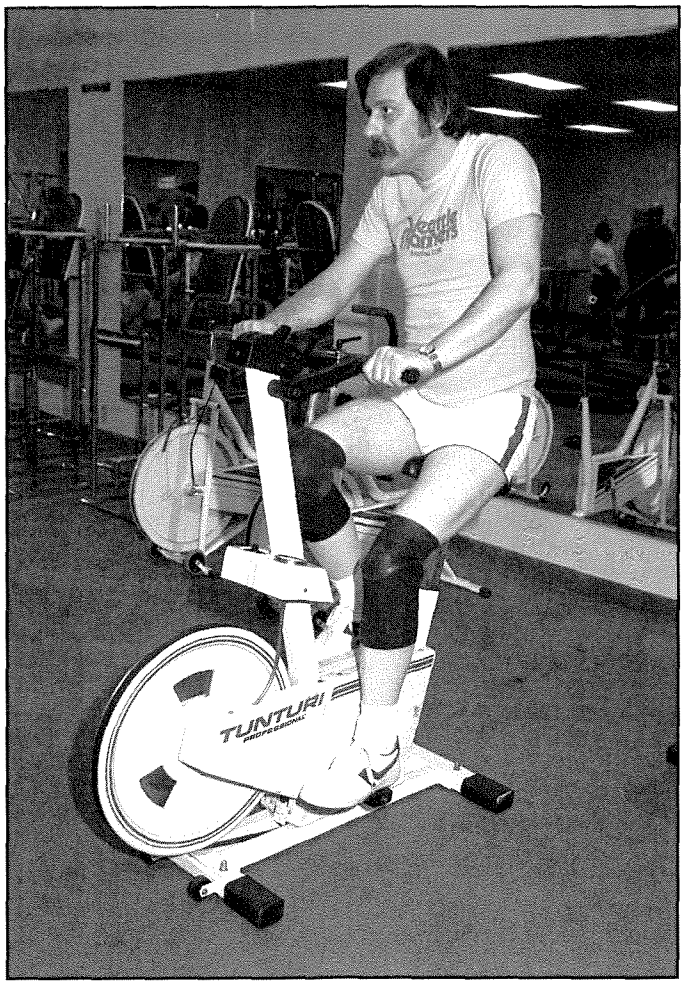
A person with lower limb loss can train in much the same fashion as a nondisabled person. When beginning a program, it is best to slowly build up tolerance and endurance for long rides, increasing distance gradually. The gradual approach will also help prevent blisters on the residual limb which could limit walking and other activities. If blisters or other painful irritations occur after even a short distance, repairs or adjustments to the socket should be made by the prosthetist immediately.

Working out socket problems by training first on a stationary bicycle is a good preventative measure before taking long outdoor rides. On a stationary bike, one can stop immediately if blisters or irritation to the residual limb develop. Whereas, on a bike path, the rider may be a distance from home and find it difficult to return without causing further injury.

Stationary bikes offer a quick and convenient workout. They are available at health clubs and gyms. A wide range of stationary bikes may be purchased for use in the home, ranging from relatively low-cost models to expensive, high-technology computerized bikes.

DAVE NELSON, BUENA PARK, CA

Vietnam veteran Jim Penseyers, who participates in the "McDonald's Race Across America," prepares for a race with the assistance of his brother, Pete. He wears toe clips and a strap to keep his prosthetic foot positioned on the pedal.

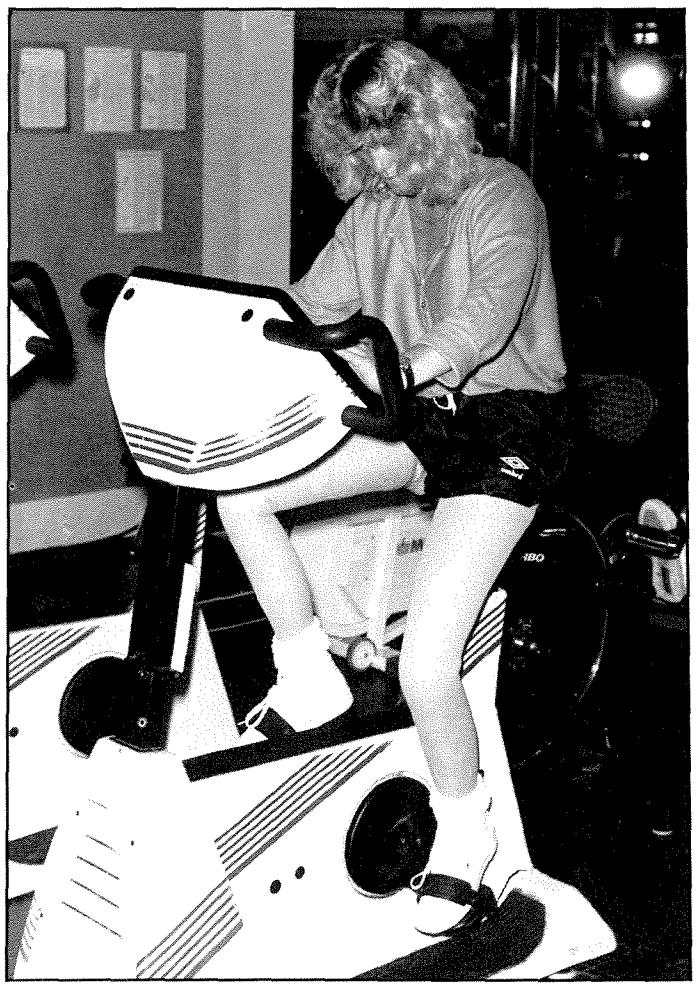


JOHN WOODMANSEE/VAMC, SEATTLE, WA
John Everett builds cardiovascular fitness as well as strength in his BK residual limbs by working out on a stationary bicycle. Note that the middle of his feet are positioned on the pedals. This provides for a more effective push and keeps his feet from slipping off the pedals (since no toe clips are available on this model).

PEDALING

Pedaling a bicycle requires both hip and knee flexion through a wide range of motion. The rider with a BK amputation may experience socket problems relating to lack of knee flexion, while AK amputees may have socket brim problems primarily related to lack of hip flexion. These prosthetic problems are most commonly addressed by using flexible sockets or lowering socket trim lines. Raising the bicycle seat will also improve socket impingement because the amount of knee and hip flexion is decreased. Flexion problems can usually be solved with these adjustments and with the assistance of the prosthetist. Adjustments are often made by trial and error while the rider exercises on a stationary bicycle. The prosthetist can often solve a problem best if he/she is able to observe while the rider is pedaling.

There may be problems in keeping prosthetic feet on the pedals. Toe clips, or custom-designed straps attached to the pedal, can keep the foot in place. A strap may be added to the pedal to secure the heel or midfoot if desired. However, toe clips on bilateral prostheses can hinder the ability to get off the bicycle quickly and it may be safer to secure only one foot. Quick-release bindings that attach the bike shoe directly to the pedal or crank arm are available.



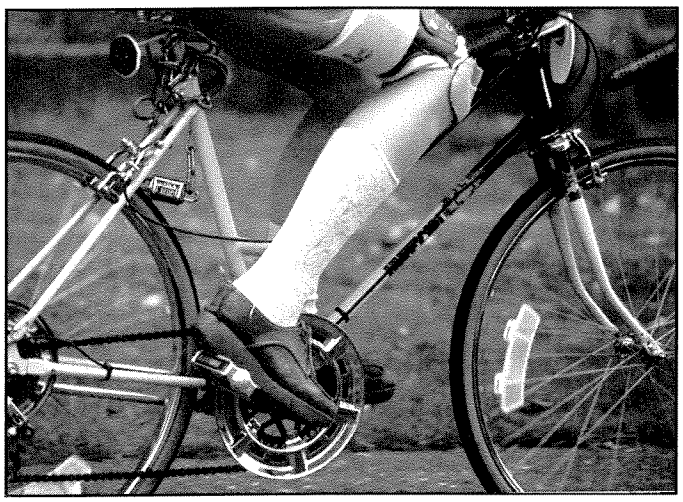
DALE TILLY/VAMC, SEATTLE, WA
Samantha Ellis tries a stationary bicycle for the first time with her Endolite prostheses. Her feet are securely attached to the pedals and the socket trim lines are designed so they do not impair her range of motion.

To gain power in pedaling, some people prefer to have the heel of the prosthesis or the peg leg positioned in the middle of the pedal since it has a more direct line of downward force underneath the socket. This adds a more effective transfer of energy to the pedal and provides increased proprioception to the rider. This method is also preferable because many prosthetic feet are very flexible in the toe areas and do not allow for an effective push on the pedal. Wearing flexible shoes such as sneakers makes pushing on the pedal particularly difficult. Those who pedal with the heel or midfoot while wearing tennis shoes or other non-biking shoes can attach a Velcro or leather strap to the pedal to prevent the prosthetic foot from slipping. Riders who use the ball of the foot for pedaling often just use toe clips.

Many riders find that a stiff-soled bicycling shoe works well when pedaling with the ball of the prosthetic foot on the pedal. If the rider does not use bicycling shoes, a stiff-soled shoe is preferable to a tennis shoe, and compensates for the flexibility that is built into most prosthetic feet. Certain feet, like the Flex-Foot, Springlite, Carbon Copy II, and DAS Foot have keels which extend to the end of the toe section. This feature makes these feet more effective than prosthetic feet with flexible soft toe sections.

Cycling power comes not only from pushing down on the pedals but also from pulling the pedal up. This is especially important when climbing long hills. Hill climbing can be particularly difficult for the biker with a prosthetic leg. Even after gaining speed and momentum, the rider must often stand on the pedals in order to work them hard enough to ascend a steep or long hill. The upward stroke in pedaling constitutes a power loss, particularly on the side with the prosthesis. However, many bikers can improve upward pulling power on the prosthetic side with good socket suspension and by wearing toe clips and bicycle cleats. The newest technique available for suspension is the 3-S Silicone Suction Socket. The 3S suspension method for BK prostheses is helpful in the upward pull on the prosthetic side.

The equipment changes described above enable the prosthesis to work for the rider. If such adaptations are not made, the rider may find that the sound leg does all the work and the prosthetic leg is just "along for the ride."



PROSTHETICS RESEARCH STUDY, SEATTLE, WA

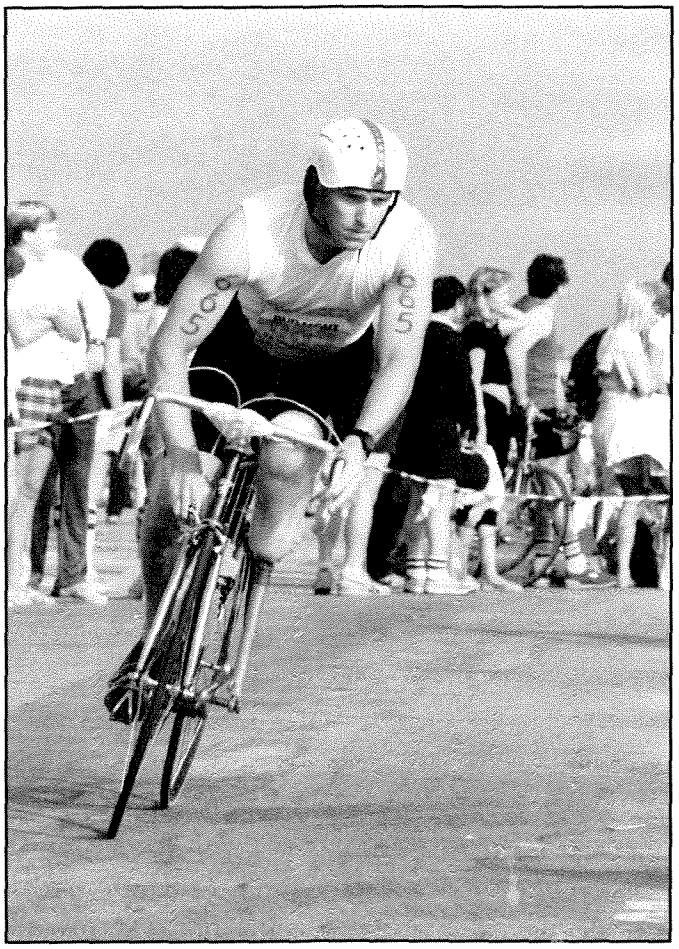
A biker wearing a BK prosthesis and stiff-soled shoes demonstrates the mid-foot position on the pedal which gives an effective push and helps keep the foot from slipping off the pedal.

GEORGE DEPONTIS, MIAMI, FL

Greg Mannino on one of his weekly rides to help stay in condition for the ski season. Greg uses an Endolite Foot, toe clips, and bicycle shoes. The Endolite ankle is multi-axial and provides for an improved range of motion.

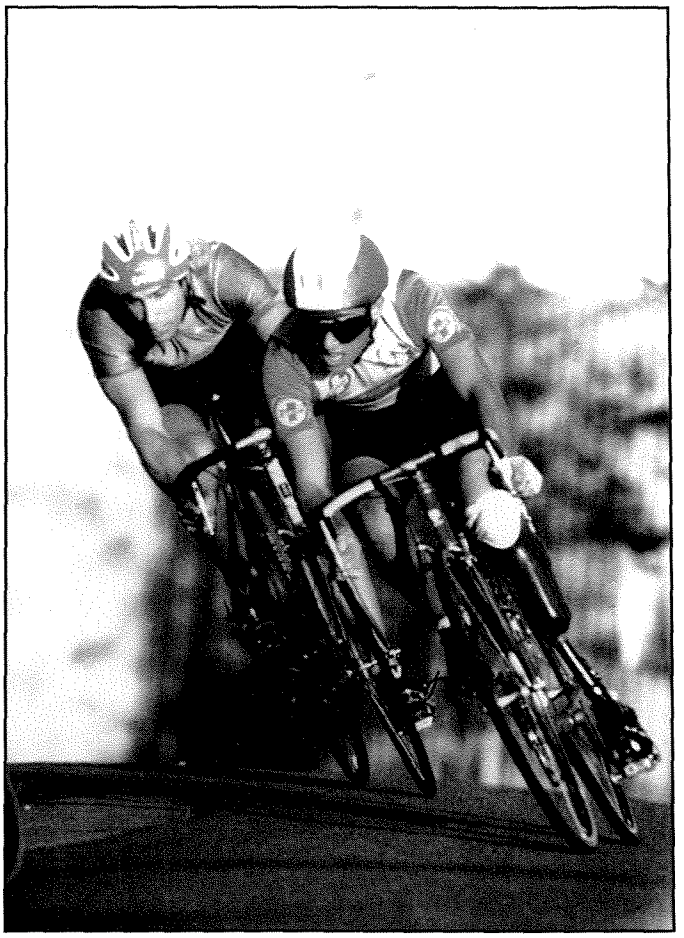
BELOW-KNEE ADAPTATIONS

A biker with BK amputation may experience limitation of knee flexion caused by the socket trim lines rubbing against the skin. Raising the seat on



GARRY STUBBS PRODUCTIONS/WEST COAST PHOTOGRAPHY, OAKLAND, CA

Lance Younger is seen competing in the cycling portion of a triathlon. The peg leg attachment on the modified pedal uses a U-joint for direct connection to the pedal and increased range of motion in the ankle.



DALE BERRY, DAW INDUSTRIES, INC., SAN DIEGO, CA

Among the world's best cyclists is Charles Dempsey, who has a left BK amputation. He was a medalist in the 1988 Seoul Paralympics and is a member of the USAAA Olympic team. His graphite DAW prosthesis allows him to obtain speeds in excess of 50 mph while racing.

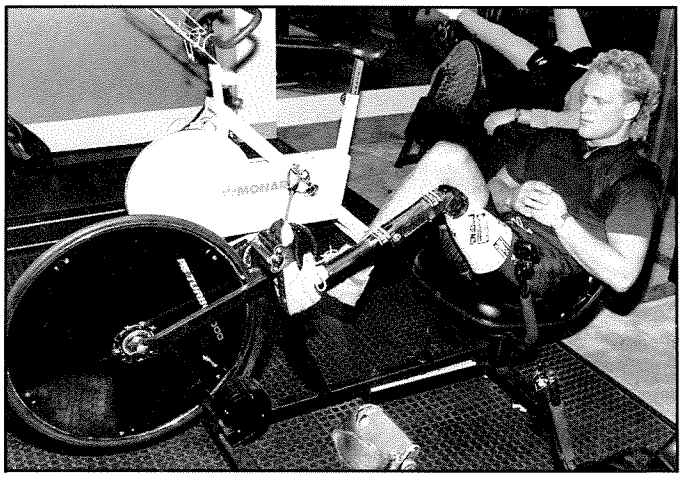
the bicycle or pedaling with the heel or midfoot can result in less need for knee flexion when going through the pedaling motion. The prosthetist may be able to lower the trim lines on the back wall of the socket to increase range of motion. However, he/she may hesitate to do this on a prosthesis for a residual limb because it can create anterior distal problems of the tibia when the prosthesis is used for walking. A diagonal trim line or lowered medial hamstring relief can be built into the prosthetic design when there is a clear intention of bicycle riding on the part of the user.

Sleeve suspension can also limit flexion of the knee to a certain degree. Some individuals use a neoprene sleeve against the skin and a latex sleeve on top of it. The neoprene prevents irritation of the back of the knee and the latex outer sleeve adds additional suspension. Sleeves are hotter than other forms of suspension, and some individuals perspire more while wearing them (many do wear them successfully). Suprapatella cuff straps are the most common form of suspension and are used by many BK cyclists. The 3S socket requires no supracondylar suspension, sleeves, or straps, and is becoming increasingly popular. It also aids in providing extra power pulling up the prosthesis while the sound leg is pushing down.

Many cyclists with BK amputation have been successful in competition. Lance Younger, who has a unilateral BK amputation, competes in triathlon events on a regular basis and generally places within

the top five against nondisabled competitors. He races with a modified peg leg that attaches directly to the pedal, which then allows increased ankle mobility because of the U-joint which is incorporated into the design. This design also makes his leg part of the bike. Younger has tried a foot in the pedals, but finds it limiting for his particular needs. He prefers peg legs for walking as well. He also prefers a supracondylar/suprapatella socket suspension design, which he finds does not limit his knee flexion.

Charles Dempsey and Jim Penseyers compete in national and international events with nondisabled cyclists. Both use regular biking shoes, toe clips, and a suprapatella cuff strap. Jim Penseyers uses a double-thickness silicone liner for bicycling, a Seattle Foot for commuting to work (over 300 miles per week), and a Flex-Foot for racing.



DALE TILLY/VAMC SEATTLE, WA

Greg Mannino demonstrates conditioning on a stationary bike in a reclining position, which is an option for those whose balance or upper-body strength is poor. This position also provides extra back support and a relaxed angle for knee and hip flexion.

ABOVE-KNEE OR KNEE DISARTICULATION ADAPTATIONS

The person with AK amputation or knee disarticulation has decreased strength due to impaired strength of the knee on the prosthetic side. Socket impingement when flexing the hip can be reduced by using a flexible brim socket. Using a Mauch SNS Knee Unit in the free-swinging mode removes resistance on the knee and provide for an easy follow-through while pedaling. (When bicycling is performed as a strengthening exercise, the knee control mechanism can be adjusted to produce a varied amount of resistance.)

When knee range of motion is greatly limited, there are two options for reducing the amount of knee flexion required for pedaling. One is to raise the seat level; the other is to put the heel, rather than the ball of the foot, on the pedal (it may be necessary to secure the heel with a strap to keep the foot in place on the pedal).

It is important to have a prosthetic socket that provides flexibility around the trim lines, either from a flexible brim or from a standard brim that has a low enough trim line to accommodate movements required for both bicycle riding and walking. CAT/CAM sockets or Narrow M/L sockets are preferred, and can be used effectively in combination with a regular walking prosthesis. A socket with suction fit and, if necessary, a Silesian belt or TES belt for additional rotary control and suspension capability, is also recommended. Riders should be aware that the foam cover on conventional AK endoskeletal units may tear from the friction caused by pedaling.

Greg Mannino, one of the top three-track snow skiers in the world, trains in the off-season by bicycling. He wears his prosthesis for conditioning, and pedals over 100 miles a week. When cycling, his prosthesis incorporates the Mauch SNS Knee Unit used in a free-swinging motion as well as the flexible brim CAT/CAM-designed socket. The flexibility of the brim affords him a wide range of unrestricted motion. He uses bicycle shoes and toe clips, which provide effective transfer of force to the pedals.

Bilateral Above-Knee Adaptations

Riding a standard bicycle requires skill, balance, and practice. Knee and hip flexion are required to pedal. Adequate knee and hip flexion for bicycling are difficult to achieve for the person with bilateral AK amputation. However, cardiovascular exercise can be performed using a stationary bicycle, an arm ergometer, or an adaptation of the row cycle, where the arms are used for pedaling either from a wheelchair or a special rowing cycle. Rowcycling (hand pedaling) attachments to wheelchairs also provide good upper-body aerobic condi-

tioning. (Such devices are available from New England Hand Cycles.)

Hip Disarticulation Adaptations

Most people with a hip disarticulation do not wear a prosthesis for bicycle riding. They usually remove the pedal on the side where there is no leg and pedal with only the sound leg. This method can work well as long as the sound leg is not overly stressed during the exercise. To further accommodate for this style of riding, the seat may be padded and turned toward the disarticulated side. This adaptation gives added pedaling strength to the sound leg, and compensates for the increased demands made to the seat design by one-legged pedaling. Cyclist Dave Kiefer, who has a hip disarticulation, has successfully competed in the "Ride Across America" several times.

SPECIAL CARE

Although bicycling is essentially a non-weightbearing activity, skin problems can occur from friction along the trim lines of the prosthesis, as well as from heat build-up. For the person with a BK prosthesis, friction may be reduced by using a DAW, Hood, or Comfort Products sheath over the residual limb. The trim lines around the brim should either be flexible or low enough to allow a full range of motion while pedaling. This will help prevent irritation in the hamstrings or femoral condyle areas, particularly for PTS or supracondylar BK prosthesis users. Spenco™ 2nd Skin™ and Spenco™ Skin Care Pads, Johnson & Johnson Bioclusive® Pads, or DuoDerm by Squibb can be used as preventive maintenance or to aid in healing blisters.

Individuals with an AK amputation who have problems with hip flexion or socket impingement should consult their prosthetists for possible modifications to the trim lines. (Flexible brim sockets and lower trim lines will help.) Modifications also can be made to the posterior seat of a quadrilateral socket, reducing the risk of skin irritation from long periods of cycling.

Bikers should take care to keep the prosthetic sockets clean. It is helpful to wash the residual limb after biking and clean the socket daily so as to prevent skin problems caused by excessive perspiration. The Hood Socket Cleaning kit, available from a prosthetist or Camp International, may be used.

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ROWING

Rowing is an excellent activity for developing physical fitness. It conditions the muscles of the back, shoulders, arms, legs, and abdomen, as well as the cardiovascular system. When pursued vigorously, rowing can provide as much exercise for the heart and lungs as can cross-country skiing, running, or swimming. Many people think that rowing requires only upper-body strength, but the proper use of the legs can greatly enhance one's performance.

Few adjustments are required in order to accommodate a lower limb amputation; one can row while wearing a prosthesis or not. However, the exercise is less effective without the use of both legs because their use increases the power and efficiency of rowing strokes.

Rowing is a highly accessible form of exercise. One can row in a boat, or on a stationary rowing machine at a health club or at home.

WATER-ORIENTED ROWING

Although rowing shells are usually lightweight (30-40 pounds), getting a rowboat into the water can be difficult for a person with lower limb loss because good balance is required in order to carry the boat to and from the water. A padded V-shaped cart can be used for transporting the boat, but it also helps to have someone assist, if the need arises. The boat can be steadied with one hand once it is set in the water beside the dock. The rower can then slide into the boat from a seated position. People who have good balance can easily master the skill of climbing into the boat from a standing position.

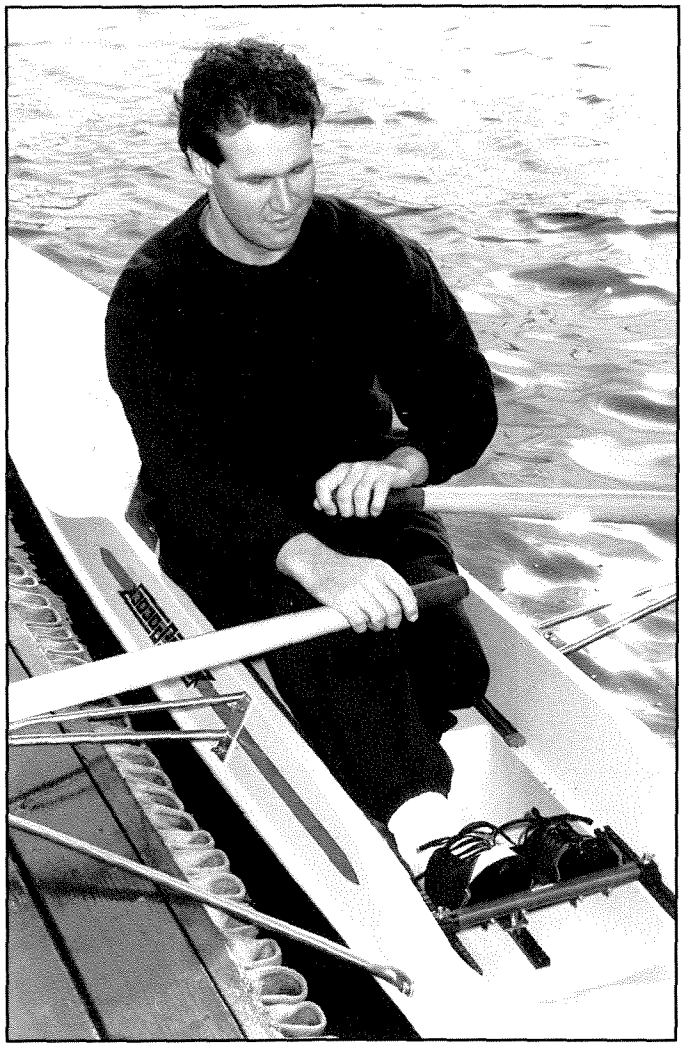
In the boat, balance is essential for safety as well as for effective rowing. It is best for beginners to start with a "wherry" (a rowboat with a wide hull) which provides for stability in the water but is not designed for speed. After gaining some experience with the wherry, a narrower, more streamlined model can be used, such as the recreational shell available from the Pocock Company.

A rower sculls or sweep-rows with oars. Sculling uses two oars and is done individually (although it can be done in teams). Sweep-rowing is used in the team sport of rowing, wherein both hands are used to work a single oar. Stationary rowing machines are designed for sculling.

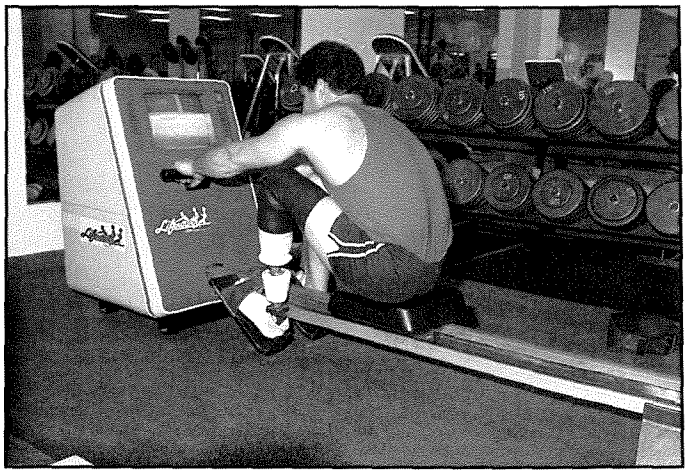
An individual can row without wearing a prosthesis, but body symmetry, as well as leg power, is sacrificed. When sweep-rowing with one oar as part of a team, a rower not wearing a prosthesis should sit with the sound limb on the opposite side of the rigger and oar. This position will provide for better balance and a more powerful stroke.

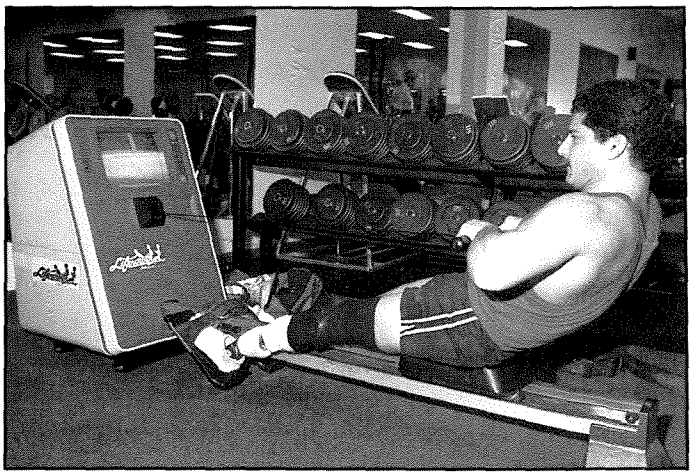
STATIONARY ROWING MACHINES

A stationary rowing machine can be the alternative for rowing a boat in water, or it can supplement the outdoor sport throughout the year. The rowing machine does not require any boating experience,



STEVE WILBER, SEATTLE, WA
Craig Rhyne, in a recreational Pocock wherry, prepares for some sculling without wearing his AK prosthetic leg.





JOHN WOODMANSEE/VAMC SEATTLE, WA
Albert Rappoport monitors his strokes on the computerized Liferower machine. He wears the ActivAnkle and the Symes Carbon Copy II Foot, a combination which allows for unrestricted range of motion in flexing the ankle and for locking while standing.

swimming skill, or ability to balance a boat in water. Although the machine does not provide the exhilaration of gliding across the water under one's own power, it does allow more people to benefit from the fitness aspects of the sport. Many competitive scullers and sweep-rowers keep in practice by using stationary rowing machines.

Stationary rowing machines are excellent for getting in shape and keeping in shape. The rowing motion is repetitive, which is best for endurance training of the cardiovascular and musculoskeletal systems. The level of resistance on the stationary rower can be adjusted to monitor progress. The muscles of the legs, arms, back, and shoulders are all being worked to provide power for the strokes, and the flywheel or hydraulic cylinders produce the resistance against these muscles. Blood is circulated through the heart in large quantities to meet the high demand for the required oxygen.

Although inexpensive hydraulic models can be purchased for use in the home, the more costly nonhydraulic machines offer features that can enhance the enjoyment and safety of the exercise. Some rowers also feel that the nonhydraulic models exert less strain on the lower back. Many health clubs have nonhydraulic, computerized "liferowers" that can be adjusted to any level of physical condition and training goals. Regardless of the user's amputation level, these machines can be used to strengthen muscles and promote overall fitness.

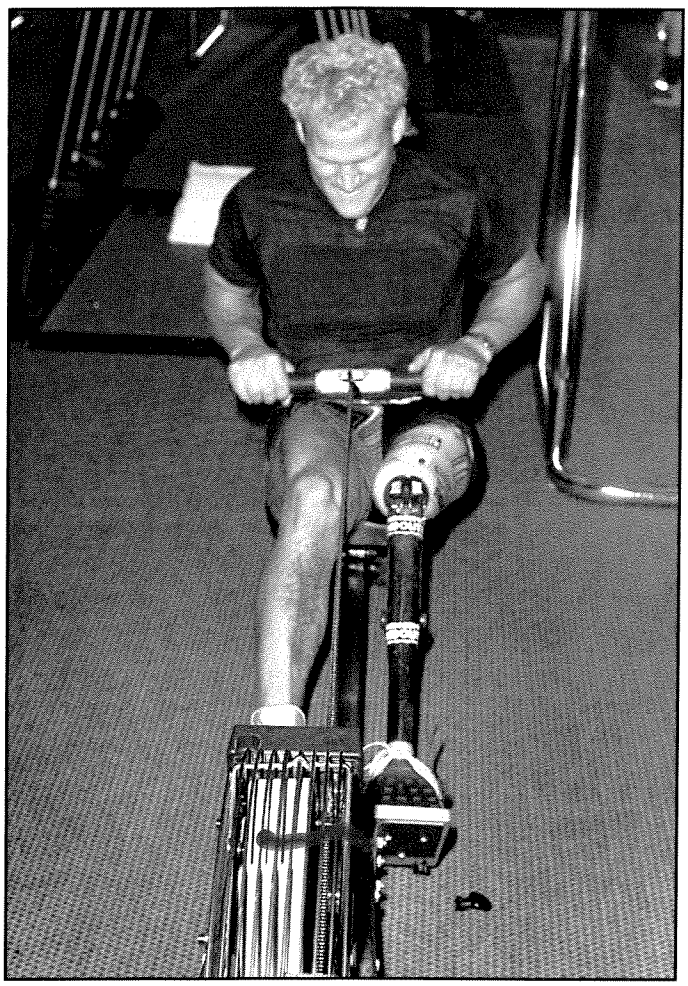
They are a good form of exercise, with or without the use of a prosthesis, for those in early postsurgical rehabilitation, because little stress is placed on the residual limb.

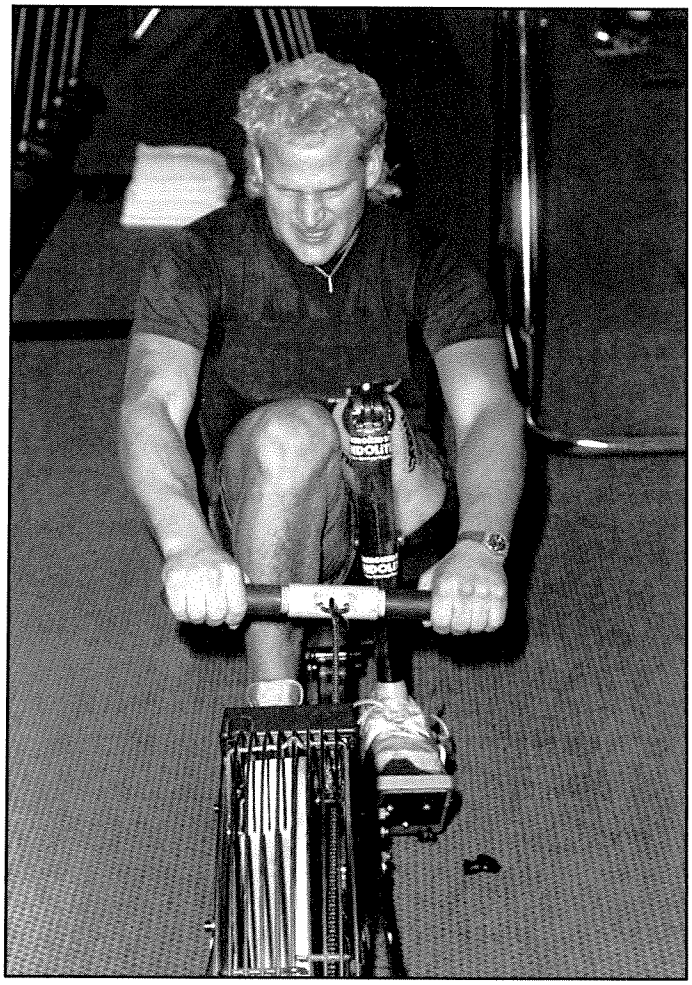
The cost of a rowing machine can vary from as low as sixty dollars to as high as several thousand dollars; therefore, it is wise to research the market carefully and test the machine before purchase.

Training on a Stationary Rowing Machine

Rowing machines closely simulate the sculling stroke with one significant difference. When in the starting position of rowing a boat, the oars are dipped into the water and the stroke begins; this action is called the "catch." The rower's body is bent forward, the knees are flexed, and the arms are outstretched. As the stroke is pulled to the "finish" or "runout" position, the body straightens and bends slightly back, the legs become extended, and the arms are brought in toward the chest or stomach. On a stationary rowing machine, the opposite occurs. The exerciser usually begins in the finish position and pushes the hand bars forward until reaching the catch position.

Aerobic benefits of stationary rowing are best achieved by performing a high number of repetitions at a low-to medium-resistance setting. The usual goal is to build endurance in order to maintain a targeted heart rate for 20 to 30 minutes of exercise 3 to 5 times per week. Once this is achieved, the number of repetitions and level of resistance can be raised to concentrate on muscle strength as well as on increased endurance.





DALE TILLY/VAMC, SEATTLE, WA

Greg Mannino works against high resistance. Newer flywheel machines like this one offer computer-controlled resistance programs so that the rower may vary the workout as strength and endurance are increased.

Efficiency of heart rate is the measure of progress in any aerobic exercise program. The rowing machine, as well as other stationary exercisers (e.g., bikes and cross-country skiing devices), allows the exerciser to monitor the heart rate and progress under controlled conditions. This is done by tracking the resting heart rate, the training heart rate, the number of minutes in exercise, and the number of strokes per minute made with the oars.

The following example of a "reference workout"[1] can be used to test the response of the heart rate to specified exercise periods:

1. 5 minutes at 30 strokes per minute at setting 1 on the rowing machine (5 strokes/10 seconds);
2. 3 minutes at 24 strokes per minute at setting 2 (4 strokes/10 seconds);
3. 2 minutes at 18 strokes per minute at setting 3 (3 strokes/10 seconds).

After each interval, the pulse should be taken and recorded. The rate should be timed for 6 seconds only and the number later multiplied by 10 to establish the rate for 1 minute. The rower should proceed to the next interval without further pause. After about 2 weeks, the reference workout should be performed again to determine if the heart rate is declining during the workout. If it is not, the rower should adjust the routine to work at a higher targeted heart rate, or should exercise for longer periods of time.

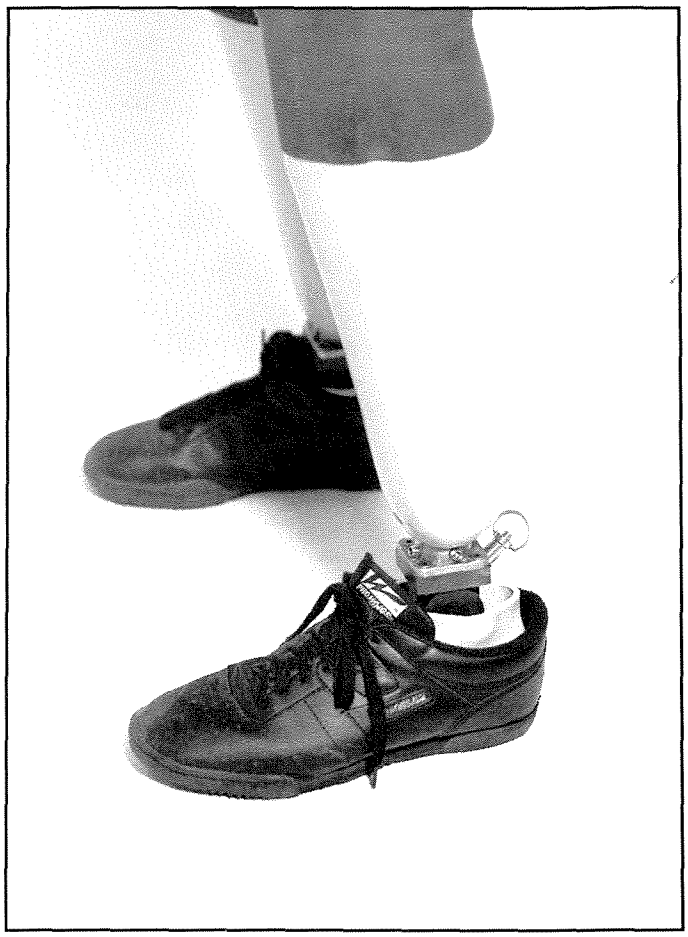
A 30-minute session of continuous rowing at a steady rate performed 4 to 6 times a week provides for good aerobic conditioning. Each session should be preceded by a 15-minute period of warm-up exercise and followed by a 15-minute period of cool-down exercise. Interval training or sprinting—mixing high-intensity with low-intensity exercise—is useful for setting up a beginning routine or for working up to longer routines.

PROSTHETIC MODIFICATIONS FOR RANGE OF MOTION

Rowing is relatively nontraumatic to the residual limb because there is little vertical impact. If irritation does occur, it will most likely be from the trim lines of the socket as the rower goes through a full range of motion to complete a stroke. If hamstring impingement is a problem for those with a BK amputation, the posterior trim lines can be modified. A lowered medial wall or a diagonal trim line that also lowers the medial side will work in many cases. When rowing in a boat, one can also sit on a cushion so that knee flexion is lessened.

The prosthetic ankle does not have as wide a range of motion as does a sound ankle. To compensate for this on a stationary rowing machine, the heel of the prosthetic foot can be placed higher off the foot board. For that reason, it is best to make the foot strap slightly loose on the prosthetic side.

When the prosthesis is used only for rowing, a removable posterior wall can be fabricated by using a clip with a supracondylar removable wedge. A proximal strap that runs circumferentially around the proximal socket can be used to help hold the removeable wall in place. The entire posterior wall



SUSAN BROWN/VAMC, SAN DIEGO, CA
The ActivAnkle can be used for rowing as well as walking. The locking pin shown on the back of the ankle unit can be removed when rowing to allow for dorsi- and plantarflexion.

can be lowered for someone with an especially long residual limb. Those with AK amputation have impingement flexing at the hip from the socket; those with BK amputation have impingement flexing at the knee. Both AK and BK sockets can be fabricated with a flexible brim made from either thermoplastics or flexible resins in order to increase comfort and range of motion while rowing.

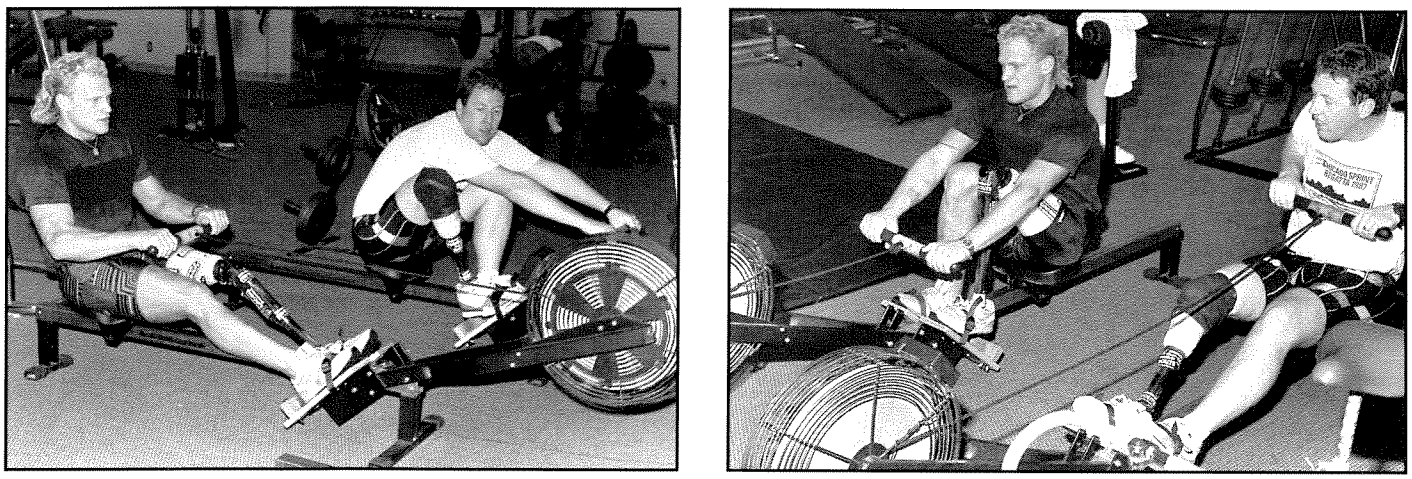
Although training and motivation are needed for competency, the rower using a BK prosthesis adaptable for rowing has a significant advantage over the rower with an AK adaptable prosthesis. This advantage is due to the knee action required for flexion and extension in rowing. There are, however, adaptations that will assist the AK-level rower. A flexible brim socket is best for obtaining full range of motion and a nonfriction knee device allows for the greatest freedom when rowing. Since suction may be lost with increased hip flexion, a TES belt or Silesian belt attached to the socket will provide for better suspension to help prevent loss of suction. Avid rowers often use a special leg designed specifically for rowing.

ADAPTING TO SLIDING SEATS

Most rowboats and stationary rowing machines are equipped with sliding seats. A seat that slides enables the rower to perform powerful extended strokes by integrating both the abdominal and leg muscles into the action. However, beginners sometimes start with a nonsliding seat in order to concentrate on other aspects of the technique.

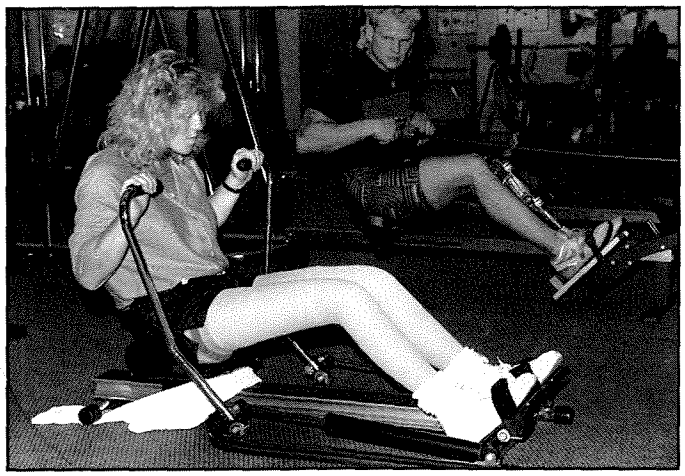
It is difficult to row a boat or stationary machine from a sliding seat if there is no movement at the ankle. The rowing prosthesis should have an ankle or foot combination that allows for a range of unrestricted motion in both dorsiflexion and plantarflexion. Over the years, various prototype ankles have been fabricated to accommodate the need for full range of motion in the ankle. The ActivAnkle is one such design and is very effective for use in sports such as rowing. It can be unlocked for complete dorsi- and plantarflexion during rowing, then locked, after rowing, into a vertical position for standing and walking. The ActivAnkle can be used on endoskeletal BK and AK systems and may also be modified for exoskeletal systems.

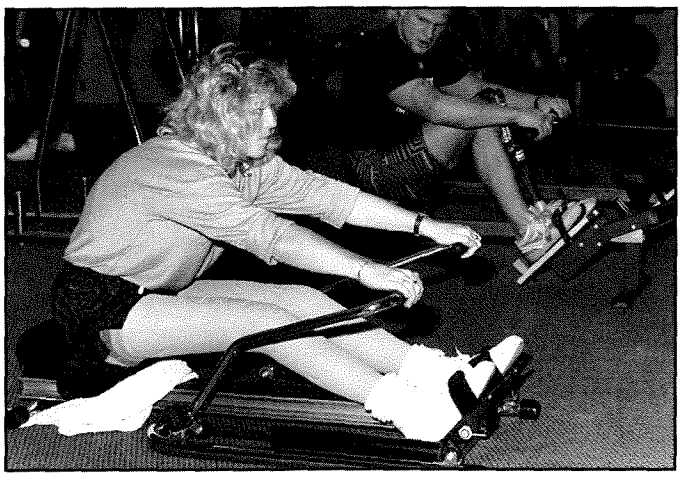
For the person with bilateral AK amputation, the sliding seat feature of most rowing machines (and boats) creates a problem of instability. Due to the lack of muscular knee control, one can easily fall backward when pulling the bars or oars toward the chest because the seat tends to slide forward at the same time. To prevent the seat from sliding, a towel may be wrapped around the seat and anchored underneath the rear feet of the machine. Another



DALE TILLY/VAMC SEATTLE, WA

Greg Mannino (unilateral AK), on the left, and Richard Hughes (unilateral BK), on the right, exercise on a flywheel machine. In the left photo, Mannino is beginning his stroke from the finish position, while Hughes is in the catch position. In the right photo, Mannino has moved to the catch position and Hughes is pulling toward the finish position. Notice that when each is in the catch position, the shins are almost in a vertical position and the knees are brought up close against the chest.





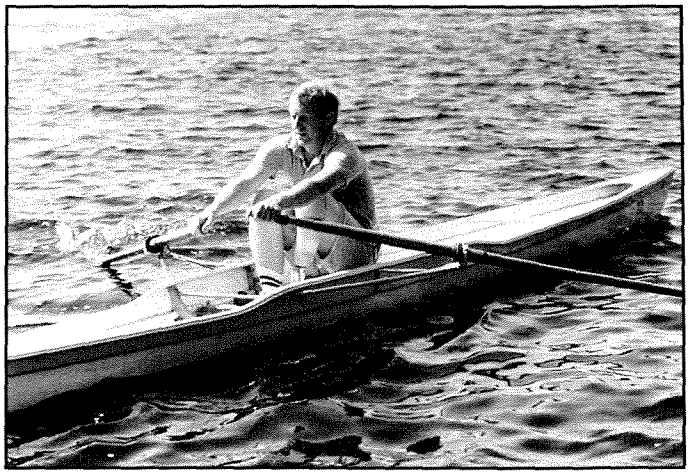
DALE TILLY/VAMC SEATTLE, WA

In the foreground, Samantha Ellis (bilateral AK) works out on an Avita 950 Hydraulic Rower. She wears Endolite prostheses which are not locked in knee extension. A towel is used to prevent the seat from sliding. Greg Mannino, exercising on the Flywheel Stationary Rower, is seen in the background. Note the difference in arm movement in each rower. The design of the Hydraulic Rower requires arm movement which is unlike the flywheel design and from sculling on water.

way to remedy the problem is to lock the knees of the prostheses in an extended position. However, for those who will use the machine on a regular basis, installation of mechanical stops is usually the best way to prevent the seat from sliding.

COMPETITIVE PURSUITS

Traditionally, athletes with lower limb loss have competed in rowing events on the same level as nondisabled athletes. As a result, organized competitive events that are exclusively among rowers with disabilities have been virtually nonexistent until recently. In 1988, the first international rowing regatta for athletes with disabilities was held in Sidney, Australia.



PROSTHETICS RESEARCH STUDY, SEATTLE, WA

Jim Clark is shown in a Pocock recreational wherry.

Jim Clark, PhD, a professor of Business Administration at the University of Washington, began rowing over 20 years ago. Even after losing his leg below the knee, he crewed as a member of the University of Washington team. He rows with a prototype flexing ankle he helped develop, and currently competes in Master's-class events. Clark says that rowing is excellent for the athlete with a limb loss because one can compete with the nondisabled athlete without any compromise in the rules, equipment, or technique. He has found it to be such a positive force in his own life that he is working to involve others in the sport by instructing them. He teaches a beginner's course at The Rowing School on Lake Union in Seattle, WA.

NOTES

1. B. Kirch, W.H. Reed and J. Fithian, *Row for Your Life.* New York: Simon and Schuster, Inc., 1985, pp. 58-59.

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CROSS-COUNTRY SKIING

Cross-country, or Nordic, skiing is rated by many experts as one of the best forms of aerobic conditioning. It promotes overall physical fitness because it requires the use of muscles in both the upper and lower body. This sport is increasing in popularity every year, partly due to the current national focus on fitness and also to the increasing expense of downhill skiing. Cross-country skiing combines an exhilarating winter sport with the breathtaking beauty of ever-changing terrain. It does not require heavy or cumbersome clothing; recent developments in wind-resistant and water-repellent fabrics allow skiers to be out in the coldest weather in lightweight, body-contoured attire.

Unlike some of the other activities included in this section, acquired skill, technique, and good physical fitness are prerequisite to the enjoyment and benefit of trail and cross-country skiing. Navigating various types of terrain in the high altitude of most cross-country ski trails places great demands on the heart and lungs, and on the body as a whole. Muscular strength and endurance are needed to sustain the activity for several hours at a time. People who are not in good physical condition, or beginners who lack skill and technique, will quickly feel the effects of a strenuous workout without traveling very far. These people should start on trails that are flat and tracked, and therefore less strenuous.

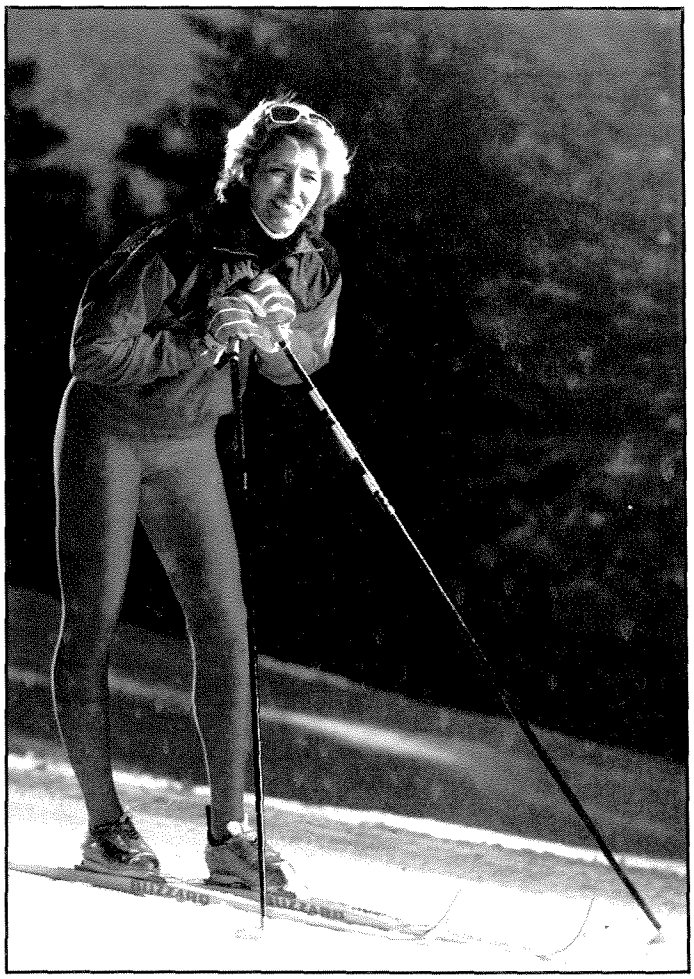
Areas designated for cross-country skiing are usually accessible to people with lower limb amputation, as well as other people with disabilities, such as paraplegics who will be using sleds. The old saying, "There is safety in numbers," certainly applies to anyone who goes cross-country skiing. No matter how skilled, those who ski in remote areas should always have at least one partner.

COMPENSATING FOR LOWER LIMB LOSS

In cross-country skiing, the legs work in a gliding motion, which can be likened to skating, that is relatively nontraumatizing to the residual limb. The gliding motion takes considerable practice to master and can be particularly challenging for those with lower limb loss. However, forward propulsion is not accomplished strictly by movement of the legs, especially on trails. Effective use of ski poles is needed to gain momentum and maintain balance. This requires upper-body, shoulder, and arm strength, as well as proper technique for coordinating the use of ski poles with the strides of the legs.

A skier who develops good technique with ski poles will be able to compensate for lack of leg strength and for the forward kicking motion that is lost as a result of using a prosthetic foot. According to Janet Penn, an avid cross-country skier, a person with BK amputation loses only about 25 percent of power on the side with the prosthesis.[1] This loss of power can be compensated for by developing upper-body strength and by perfecting techniques. Using the ski poles effectively for speed, additional balance, and push-off can substantially offset the lack of leg strength on the side with the prosthesis.

JON BORK/MAUCH LABS, DAYTON, OH
Greg Mannino enjoys the aerobic benefits of cross-country skiing. He uses the Mauch SNS Knee Unit with a CAT/CAM socket and Endolite prosthesis with the Stabilized StanceFlex (Bouncy) Knee, and Endolite Foot and Multiflex ankle. Mannino was the top Men's Three-Track Skier and was an Olympic Medalist on the U.S. Disabled Downhill Ski Team, 1988 Winter Olympics, Calgary, Canada.



MODEL AND INSTRUMENT DEVELOPMENT, SEATTLE, WA
Racing champion Janet Penn pauses for a moment from cross-country skiing. She skis with the Seattle Foot and wears wind-resistant and water-repellent lightweight clothing that barely reveals her prosthetic left leg.

PROSTHETIC ADAPTATIONS

Skiing requires coordination of the body at the ankles, knees, hips, and trunk. Thus, the types of prosthetic adaptations needed will be determined primarily by the level of amputation.

For those with BK amputation, a walking prosthesis is usually adequate but may require modification to allow full range of motion and flexion. Energy-storing feet are helpful. Many competitive skiers use the Flex-Foot, which is effective in achieving the "kick" associated with cross-country skiing, since the keel of the foot is unloaded at toe-off with great force. The Flex-Foot is rigid in the mediolateral plane, which permits the ski to react more effectively when movement is initiated. Unlike a foam-covered foot or multi-axis foot that requires moving past a certain point before the motion is transferred to the ski, the Flex-Foot translates each movement almost directly to the ski.

Mediolateral knee stability is very important in controlling the prosthesis and ensuring that the ski is responsive to prosthetic forces. Side joints and lacer, or a knee brace, can help maintain mediolateral stability and limit rotation of the residual limb within the socket. However, some people find the side joints and lacer cumbersome, and the added stability may not be worth the added weight and loss of motion. Specially designed BK ski legs, which may include modified trimlines for greater knee flexion as well as alignment variations different from an everyday walking prosthesis, are available for the avid skier.

Skiers with AK amputation will do best using a hydraulic knee prosthesis, such as the Mauch SNS Knee Unit, as well as a multi-axis foot. AK skiers generally use a double-pole and single-kick technique in the tracks. The gliding or skating motion is difficult to achieve with an AK prosthetic leg, but one can become proficient with practice.

OFF-SEASON TRAINING

Many cross-country skiers train during the warm months by using roller-skis, which are skis with an aluminum track and binding. Wheels attached to the underside have a ratchet device that prevents them from rolling backward. This enables the skier to feel the kicking motion used on cross-country trails. The gliding motion can be achieved with roller-skis, and one can practice with ski poles to develop arm-leg coordination.

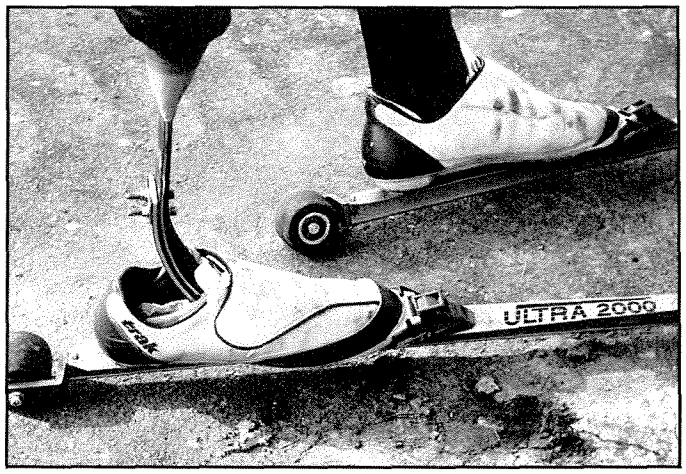
Using roller-skis on a concrete surface does involve some risks. Falling can be dangerous since concrete is a hard surface, unlike snow-covered ground. Protecting the sound limb is an important consideration, and this activity should be pursued with caution. In fact, some experts recommend the use of roller-skis only after one has learned to ski on snow.[2]

CROSS-COUNTRY SKIING MACHINES

The indoor version of cross-country skiing is a stationary exercise device that closely simulates the arm and leg movements in skiing. As in actual skiing, the ski-simulator requires practiced technique to be effective. Once skill is developed, skiing machines are excellent for aerobic conditioning as well as for keeping fit for this sport.

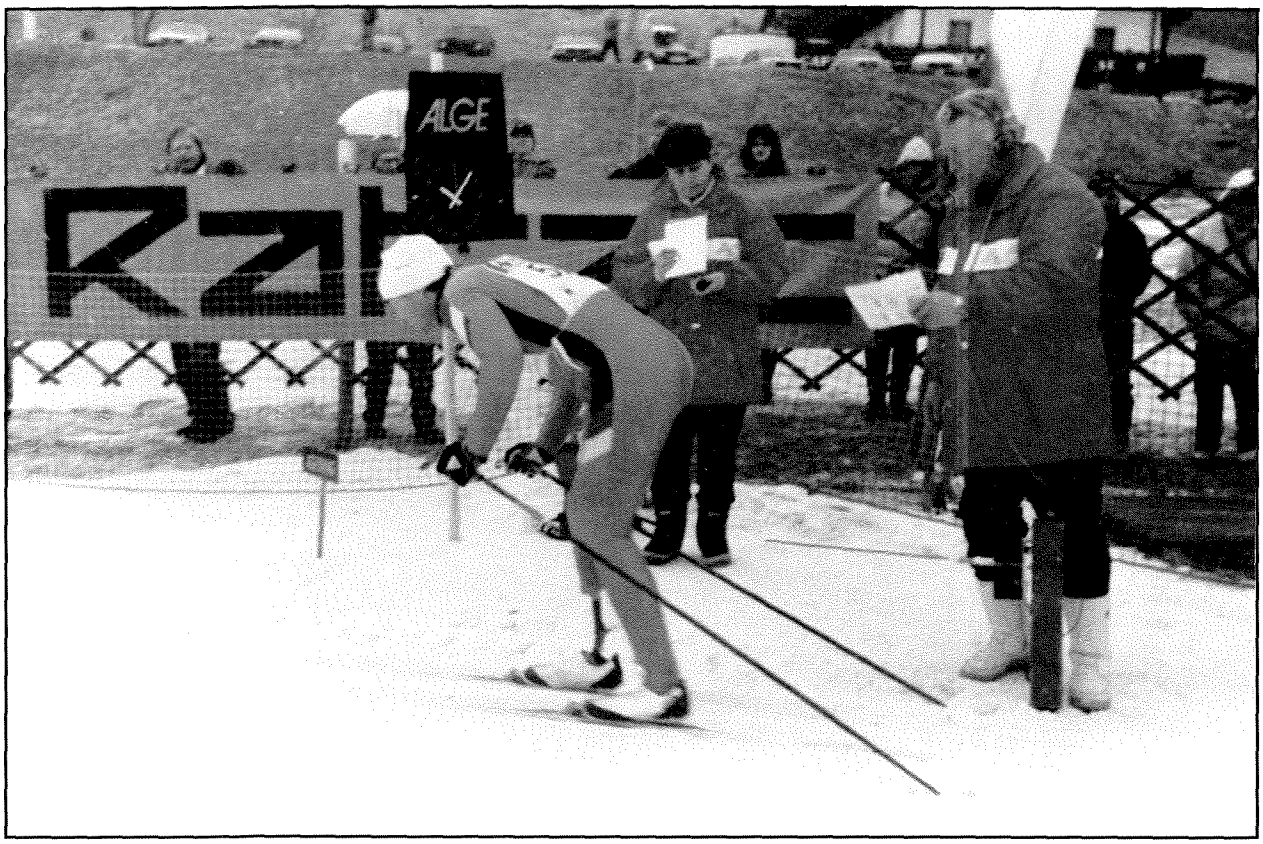
The ski-simulator is equipped with short skis that have slippers to hold the feet in place. The skis rest on rollers. Cables that work against an adjustable resistance device take the place of ski poles. Arm and leg movement can be coordinated in the same way as in cross-country skiing. Resistance should be set low for the beginner and then gradually increased. To gain maximum aerobic benefit using a ski-simulator, one should maintain a target heart rate for 20 to 30 minutes at least 3 or 4 times a week.

Maintaining balance and coordination on a ski-simulator, such as the Nordic Track, is often difficult for one who has never skied cross-country, and may be particularly so for a person wearing a lower limb prosthesis. The prosthetic foot may need to be secured at the toe to prevent it from coming out of the slipper, since there is no binding (as on a regular ski) to hold it in place.



AMERICAN ACADEMY OF ORTHOTISTS AND PROSTHETISTS
The Flex-Foot is shown positioned on the roller-ski and in the kicking motion of cross-country skiing.

Most ski-simulators emphasize leg exercise. They do not develop the arms in the same way as in snow skiing because the upper body does not really



RICK RILEY, CP, RENO, NV

Rick Riley in the starting position for the World Championship Skiing competition held in Sweden in 1986.

assist the glide or the movement of the legs. The skis move independently of the arms. This is one reason why training on a ski-simulator is often difficult or impossible for some people with lower limb amputation.

COMPETITIVE PURSUITS

Rick Riley, a certified prosthetist who has a below-knee amputation, was rated tenth in the world among disabled cross-country skiers. He competed in the 1984 Olympic World Winter Games held in Innsbruck, Austria, and in the 1986 World Championship for Skiing in Sweden.

Riley prefers a Flex-Foot prosthesis for skiing because he feels it gives him increased edge control. Modifications to his prosthesis have also helped him achieve his skill. When on skis, his foot is inset slightly more than normal, one-half to one inch in relation to the socket. He says this angle is helpful to him because when a cross-country skier is "skating," the weight is being transferred from one side to the other. The angle of inset keeps his foot underneath him as he moves from side to side, and he does not need to overcompensate with shifts in body position to maintain balance and rhythm.

Riley is the only disabled racer at the national level who is also a prosthetist. He feels that most people who have a BK amputation do not need a special leg to enjoy cross-country skiing for fitness and recreation. But, for those who wish to compete, the best alignment possible is needed and a special leg for skiing is helpful.

NOTES

1. Janet Penn, top ranked BK women's Nordic skier, U.S. Disabled Ski Team, National Handicapped Sports and Recreation Association, personal communication with author, August 1988.

2. H.B. Simon and S.R. Levisohn, *The Athlete Within.* Boston: Little, Brown & Company, 1987, p. 229.

21

GAME SPORTS

The sports described in this chapter promote both aerobic and anaerobic physical conditioning as well as skill development. For best results, they should be combined with a pure aerobic type of activity and a program of weights, stretching, and calisthenics. Proper warm-up and cool-down exercises will be necessary (see Chapters 5 and 6). There are many other game sports that require skill but are less strenuous and do not offer high-level aerobic benefits, such as golf, bowling, and baseball.

Handball, tennis, racquetball, squash, basketball, soccer, hockey, and lacrosse are good supplemental activities to a regular physical conditioning program because they are relatively strenuous sports that provide good aerobic exercise, especially if played on a regular basis. They require and maintain both aerobic and anaerobic conditioning. These sports are not as repetitive in their motions as are running, rowing, swimming, bicycling, or cross-country skiing. The games emphasize strategy and a variety of actions to score points against opponents.

As in any sport, the player must develop the ability to perform the basic skills required: running (sprinting short distances or running down a field or court); ball-handling or racquet/stick skills that require good hand-eye coordination; and upper-body strength. Soccer requires strenuous use and coordination of the lower limbs. All of the games discussed in this chapter develop a sense of quickness and balance.

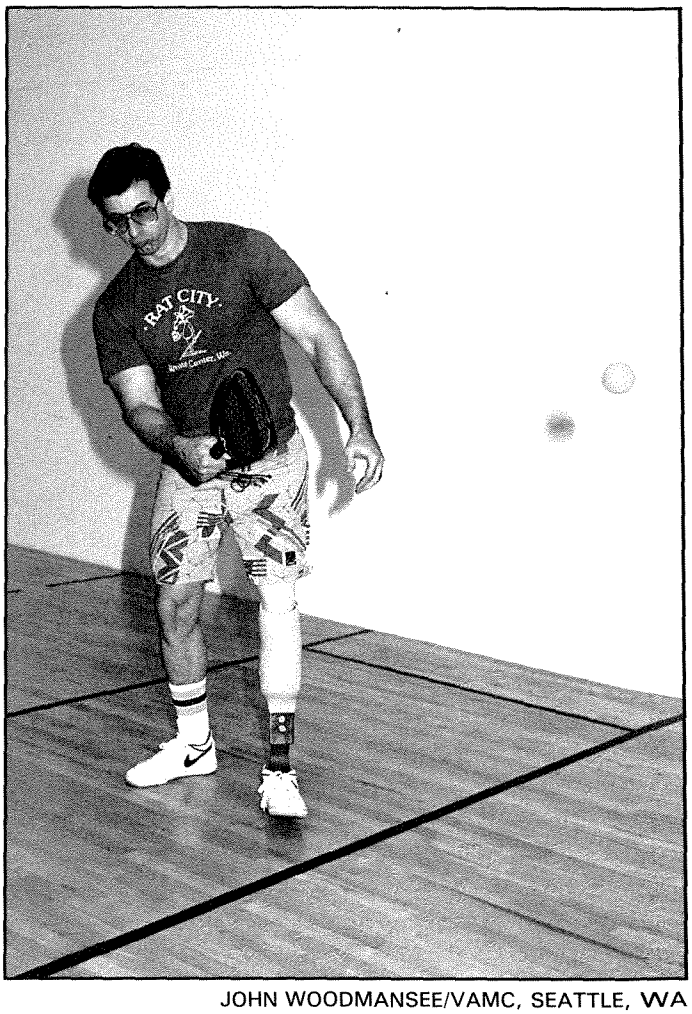
Once the game skills are mastered, the player must have the strength and muscular endurance needed for distance running, as well as the flexibility and agility needed for quick body movement. These are necessary in order to prevent injuries and will contribute to the satisfaction of high performance in play. It is always best to begin a new activity slowly and work up to full potential gradually. Thus, it may take time to become fit enough to keep up with the others in an active game sport.

Most game sports are not continual steady-state exercise, which often makes it difficult to monitor aerobic progress. Time-outs, brief rest periods, or other interruptions in the game allow the pulse to drop momentarily during the course of play. Because a good aerobic training program requires maintenance of a target heart rate for 20 to 30 minutes, at least 3 times per week, one must train for longer periods when using game activities for aerobic conditioning.

Endurance levels increase more rapidly in game sports when the participant also engages in some form of steady-state exercise on a regular basis (e.g., running or swimming). Many athletes run and/or lift weights during the off-season, which increases their strength and aerobic capacity. Thus, they are in better condition for competition in the regular game season during which a reduced program of running, weight lifting, and calisthenics is continued for fitness maintenance.

Handball, tennis, racquetball, and squash require fast reflexes and agility. Individuals with lower limb loss may prefer racquetball over other racquet sports because of the smaller court size involved and

STEVE WILBER, SEATTLE, WA
Kevin Wilson had a collegiate soccer scholarship just prior to losing his left leg below the knee. He now competes in both crutch soccer and stand-up soccer leagues with nondisabled players.



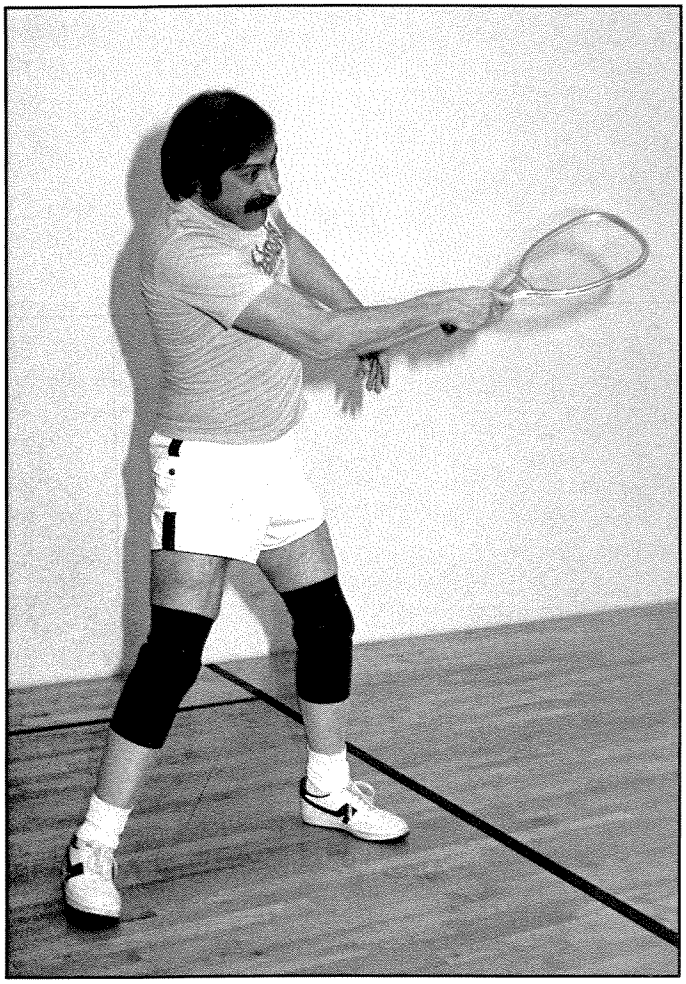
JOHN WOODMANSEE/VAMC, SEATTLE, WA
Mike Nitz, serving a ball during a racquetball game, wears a CAT/CAM Flexible Brim AK Suction Socket, Mauch SNS Knee Unit with the Flex-Foot prosthesis.

the shorter distance to be covered when running. However, speed is essential and there is less time to react when playing on a smaller court. Speed can be a problem when competing with nondisabled players; therefore, a player with a disability has to develop game strategies and good ball placement in order to be competitive.

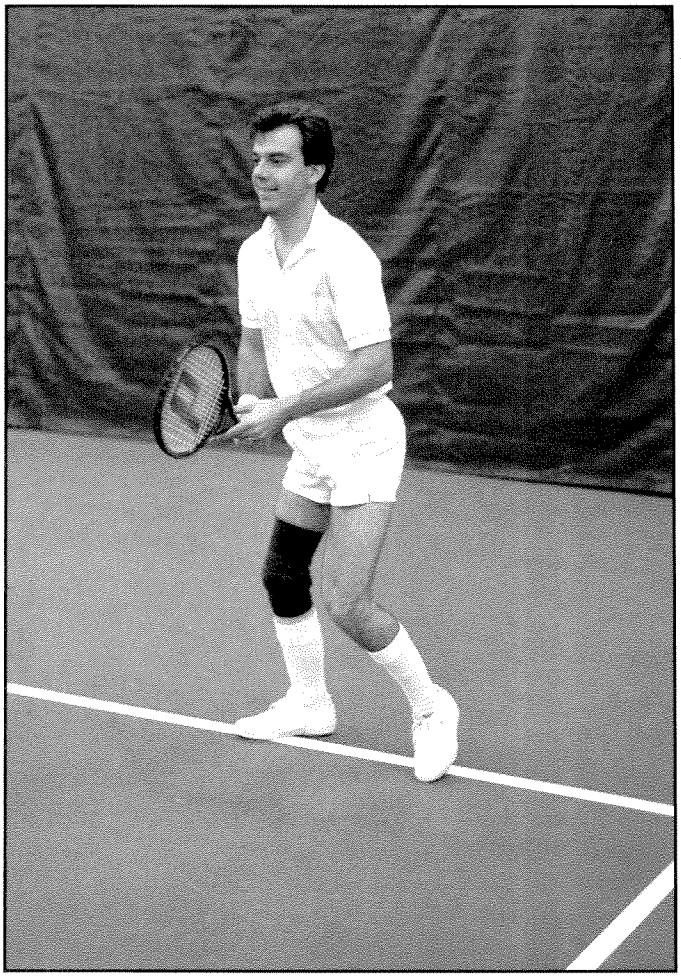
Throughout the game, the player must be able to run (when necessary) in order to get adequate cardiovascular exercise from the activities. Therefore, the prosthesis must fit the residual limb well. If not, blisters or skin irritation will occur and prosthetic adjustments may be necessary. If complications persist, it may become necessary to choose another activity.

Hockey, lacrosse, soccer, and basketball require continuous movement by the players; a lot of distance is covered on the field or court during the course of the game. The person with lower limb loss who cannot keep up the required pace probably will not get an adequate aerobic workout, and the player may not fully enjoy the game. However, for someone who really wants to play one of these sports, there are some options. One option would be to select a position on the field that does not require a great deal of running, such as goalie. Although this would allow for participation as an effective member of the team, it would limit the aerobic benefits of an active team sport.

Hockey and lacrosse involve the use of a stick to maneuver the ball and require the player to cover



JOHN WOODMANSEE/VAMC, SEATTLE, WA
John Everett drives a hard shot into the wall. He uses Seattle Feet and the ActivSleeve Suspension system on his exoskeletal prostheses.

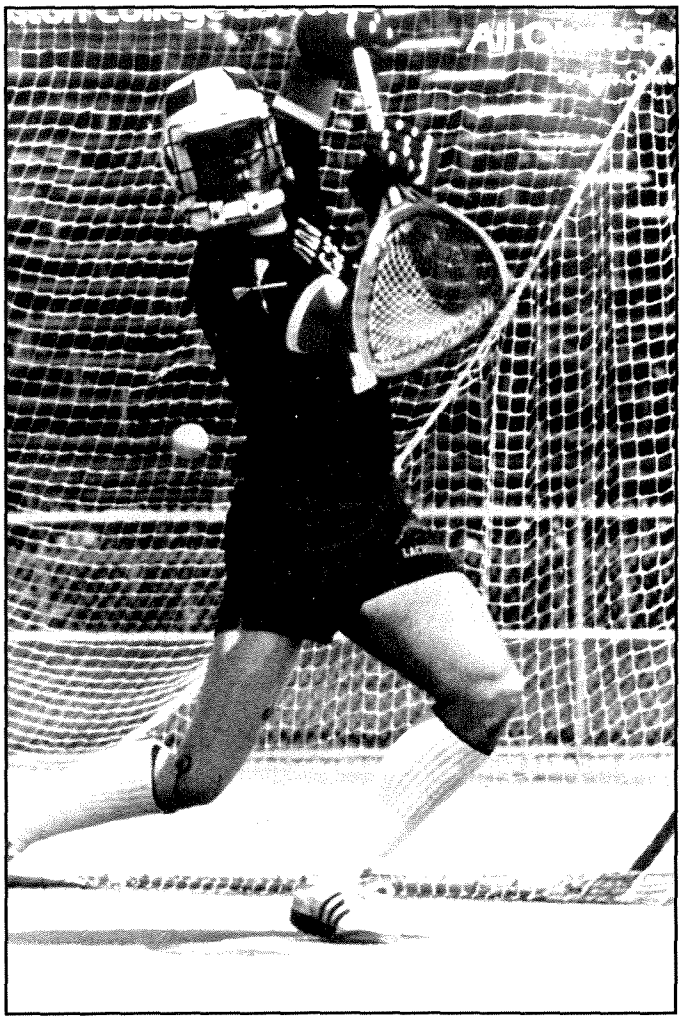


MARTIN BRUMER, SANTA MONICA, CA
Scott Fickenscher demonstrates his skill as an accomplished tennis player. He wears a Seattle Foot and Ankle with Otto Bock adapters, New Skin protective coating on the endoskeletal foam cover, PM Liner, DAW Sheath, and the ActivSleeve Suspension System.

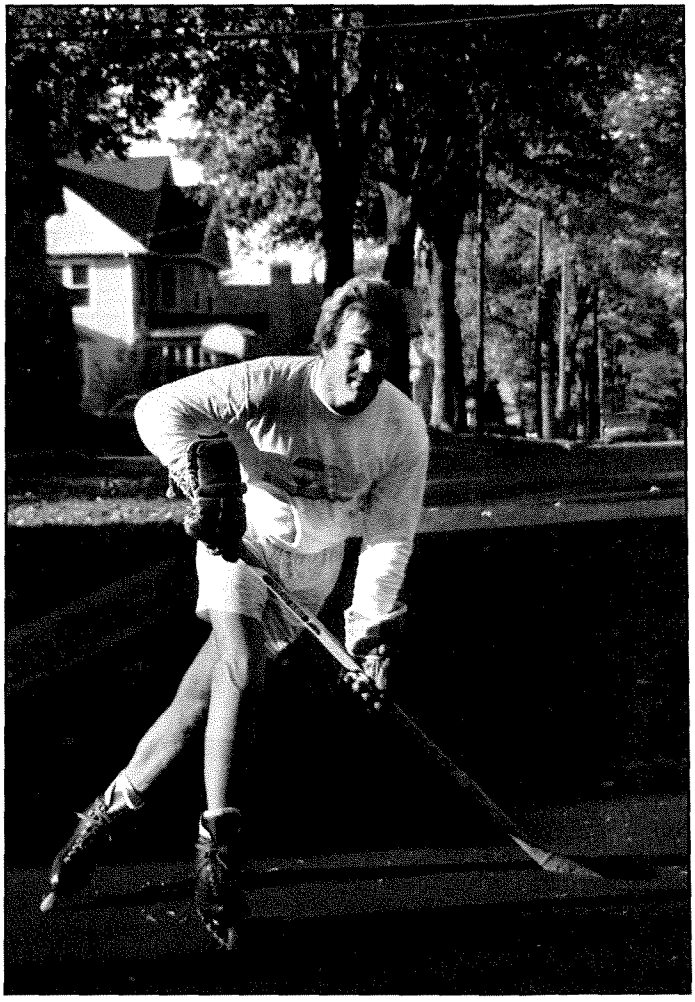
distances at a fast pace. **Roller hockey or ice hockey** may be better choices for the person with lower limb loss than would field hockey because no running is involved. These sports are comparatively nontraumatizing to the residual limb because they require movement of the legs in a gliding motion, which does not have the vertical impact of running. In roller or ice hockey, a person who is disabled can compete more favorably with nondisabled opponents.

People with lower limb loss often find roller hockey easier to play than ice hockey because the wheels of the roller skates provide a wider base than the blade does on ice skates. There is also more ankle mobility allowed in roller-skating because of the adjustability of the trucks that attach to the skate wheels. Beginners should start with roller skates rather than roller blades, which require greater balance.

When ice-skating, some people with BK amputation find that leaning their prosthesis forward over the ball of the foot helps them maintain balance and aids in push-off. This may require a special alignment of the prosthesis, or modification of a walking prosthesis (by adding wedges to the heel) to make the prosthetic leg lean forward. Individuals with AK amputations will find ice- or roller-skating difficult because of problems with knee stability (those with the Mauch SNS Knee Unit will find it easier to ice- or roller-skate when it is combined with the Endolite ESK unit).



CHARLIE FRIED/ABILITY MAGAZINE, LOS ANGELES, CA
Jeff Keith plays goalie on the varsity lacrosse team at Boston College.



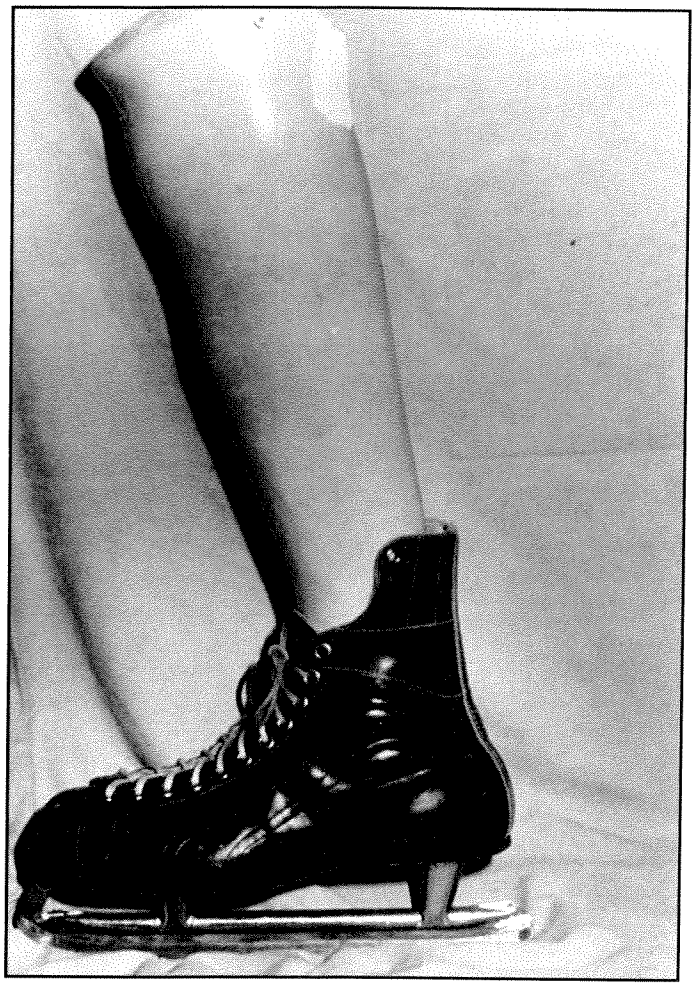
INSTITUTE FOR THE ADVANCEMENT OF PROSTHETICS, LANSING, MI
Dale Conlin is shown roller-blading. He wears a total-surface-bearing socket design, Peyton Massey silicone gel insert, latex Michigan sleeve suspension, Otto Bock titanium components, Seattle Foot, and New Skin cosmesis.

Soccer is very demanding on the legs. Although some athletes with disabilities can keep up with the nondisabled in playing soccer on a full field, most find there is too much strenuous running and kicking involved for them to be competitive. Indoor soccer, which has a smaller "field," is a good alternative.

People who find it difficult to run while wearing a prosthetic leg can still play soccer by removing the prosthesis and using crutches. Don Bennett of Seattle, Washington, has developed **crutch soccer**, a new form of soccer for nondisabled players and those with disabilities. Crutch soccer is fast-moving, very competitive, and provides an excellent muscular and aerobic workout. Teams can be made up of players with and without disabilities. All players use crutches, but may not hit the ball with them. The nondisabled players must keep one leg off the ground at all times (it must be the same leg throughout the game). The nondisabled players soon realize the challenge of playing on crutches.

The crutch soccer team in Seattle has hosted several international tournaments; coach Bill Barry has traveled extensively to promote the game throughout the United States, Canada, South America, England, and the former Soviet Union.

Basketball is one of the fastest-moving team sports. Playing it requires agility in jumping and running and a high degree of ball-handling skill. The most difficult challenges for those with lower limb



PROSTHETICS RESEARCH STUDY, SEATTLE, WA
Modifications have been made to this below-knee prosthesis to move the weight line forward in order to accommodate the leg position for ice skating. In the forward lean shown, the socket falls over the middle section to the ball of the foot.

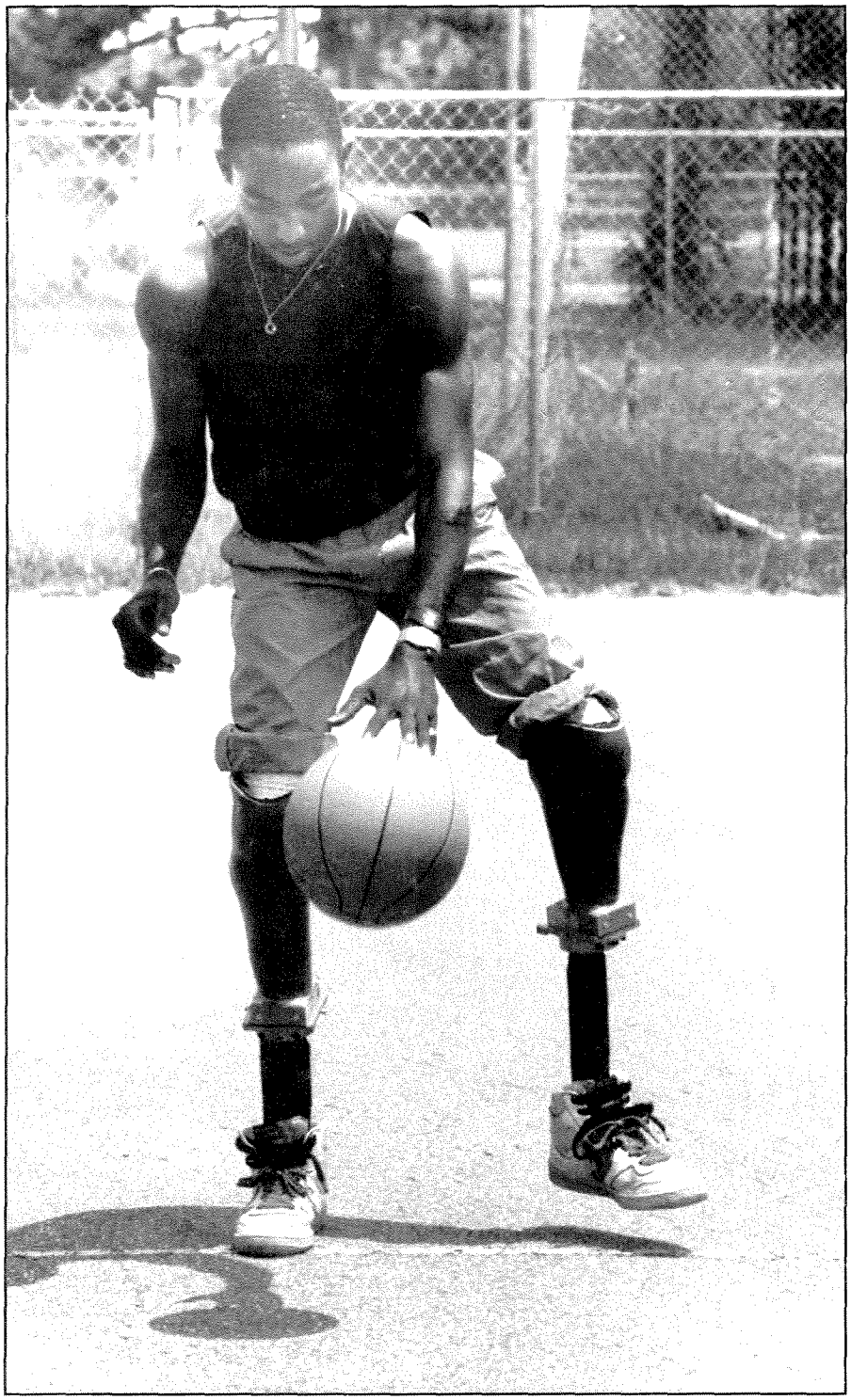
SEATTLE TIMES, SEATTLE, WA
Steve Wilber (center) of the Seattle Crutch Soccer Team is in control of the ball.

amputation are changing direction quickly while running, and running the distances required without getting blisters.

Regardless of the nature and level of amputation and the condition of the residual limb, the best-fitting prosthesis may still not be adequate for running during an entire game of basketball. But there are other ways to be effective in the game, such as developing sharp aim and shooting skills. Outside perimeter shooting ability will certainly enhance a person's value as an effective member of the team.

Individuals who simply cannot tolerate the pressure caused by continuous running will find it too difficult to participate in full-court basketball. Playing half-court basketball, where less running is required, can be an enjoyable alternative. There is also the option of playing wheelchair basketball. This is often a good choice for those with high-level and bilateral AK amputation or hip disarticulation. There are competitive leagues and tournaments in many communities throughout the United States, and wheelchair basketball teams are very popular.

On the national level, competitive basketball tournaments for persons with disabilities are sponsored each year by the U.S. Amputee Athletic Association and the National Wheelchair Basketball Association.



VERN MILLER/NEWS-HERALD, PANAMA CITY, FL

Tim Flowers practices dribbling with his newly-fitted Flex-Feet, which are still on their alignment units.

SPECIAL RESOURCES RELATED TO SPORTS FOR THE DISABLED

American Amputee Foundation
Jack M. East, Executive Director
Box 55218, Hillcrest Station
Little Rock, AR 72225
(501)666-2523

American Wheelchair Bowling Association
Daryl L. Pfister, Executive Secretary-Treasurer
N54 WI5858 Larkspur Lane
Menomonee Falls, WI 53051
(414)781-6876

Amputee Soccer International
Mr. Bill Barry
c/o Johnson and Higgins
1215 Fourth Avenue
Seattle, WA 98161
(206)292-1900

Amputees in Motion
Carol Hall, President
P.O. Box 2703
Escondido, CA 92025
(619)454-9300

Handicapped SCUBA Association
Jim Gatacre, Program Director
116 West El Portal, Suite 104
San Clemente, CA 92672
(714)498-6128

International Foundation for Wheelchair Tennis
Peter Burwash, President
2203 Timberlock Place, Suite 126
The Woodlands, TX 77380
(713)363-4707

International Wheelchair Road Racers Club
Joseph M. Dowling, President
30 Myano Lane Box 3
Stamford, CT 06902
(203)967-2231

National Amputee Golf Association
Bob Wilson, Executive Director
P.O. Box 1228
Amherst, NH 03031
(603)673-1135

National Foundation of Wheelchair Tennis
Bradley Parks, President
940 Calle Amancer, Suite B
San Clement, CA 92672
(714)361-6811

National Handicapped Sports
Kirk M. Bauer, Executive Director
1145 19th Street, NW, Suite 717
Washington, DC 20036
(301)652-7505

National Wheelchair Athletic Association
3595 East Fountain Blvd. Suite L1
Colorado Springs, CO 80910-1740
(719)574-1150

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

National Wheelchair Softball Association
William J. Scebbi, Executive Director
P.O. Box 33150
Denver, CO 80233
(303)452-1212

U.S. Amputee Athletic Association
Dick Bryant, President
P.O. Box 560686
Charlotte, NC 28256
(704)598-0407

U.S. Wheelchair Racquet Sports Association
Chip Parmelly
1941 Viento Verano Drive
Diamond Bar, CA 91765
(714)861-7312

GLOSSARY

BELTS AND BOOTIES

Total Elastic Suspension Belt
The TES Belt helps suspend the AK socket.

Inner Neoprene Bootie
When engaged in sports or exercise without a prosthesis, the Inner Neoprene Bootie can protect the residual limb.

BRACES

Lenox Hill Brace
A brace on the sound side helps prevent or stabilize an injury when playing high performance sports such as soccer, basketball, or running.

FEET AND ANKLES

ActivAnkle
The ActivAnkle accommodates the need for full range of motion in the ankle. It can be unlocked for complete dorsi- and plantarflexion then locked into a vertical position for standing and walking.

D.A.S. Foot
The D.A.S. or Dual Ankle Spring foot, provides energy storage and multiaxis function through the double spring design.

Flex-Walk Foot (Flex-Foot, Inc.)
The Flex-Walk Foot is designed especially for walking. It has a lower spring rate than the full length Flex-Foot, is made of graphite, and produces increased push-off at the toe-off phase of gait.

Greissinger Foot (Otto Bock, Inc.)
The Greissinger MultiAxis Foot works well on uneven terrain.

IPOS 6-Way Ankle
The IPOS 6-Way Ankle provides multiaxis mobility, is lightweight, and good for walking.

Kingsley Beachcomber Foot (Kingsley Mfg.)
The Kingsley Beachcomber Foot is the only foot that was originally designed for use in the water. It is also flat-bottomed for barefoot walking.

Kingsley STEN Foot
The Kingsley STEN Foot (ST-Stored + EN-Energy = STEN) has a flexible wooden keel. Rubber plugs are inserted for improved performance. It is available in all heel heights.

Otto Bock Dynamic Foot (Otto Bock® Orthopedic Industry Inc.)
The Dynamic Foot offers a lightweight design incorporating energy storage and a multiaxis function.

Otto Bock Single Axis Foot
The Otto Bock Single Axis Foot is an exoskeletal prosthesis and is excellent for walking.

Quantum Foot
The Quantum Foot utilizes leaf springs inside a modular foot shell. It has inversion and eversion capabilities that adapt to both the exo- and endoskeletal prostheses. The keel can be modified to accommodate various weight and activity levels.

Sabolich Foot
The Sabolich Foot is designed to mimic the natural arch of the human foot.

Otto Bock SACH Foot
The SACH is a Solid Ankle Cushioned Heel prosthetic foot.

SAFE Foot II
The SAFE (stationary attachment flexible endoskeleton) Foot is a unique combination of energy storage and multiaxis function.

Seattle Foot
The Seattle Foot stores energy by employing a plastic keel or leafspring embedded in a cosmetic foam foot.

Seattle Light Foot
The Seattle Light Foot is much lighter than the original version and can accommodate many of those individuals who have a Symes amputation.

Seattle Light Foot with Seattle Ankle
This lighter weight combination provides increased function and energy storage.

Springlite™ Foot
The Springlite™ energy-storing foot is a lightweight structure composed of a rubber compound between layers of graphite. It provides a smooth rollover with energy storage, increased comfort, and function.

KNEES

Endolite Stabilized StanceFlex Bouncy Knee (a.f.i. Endolite)
The "Bouncy" Knee from Endolite has a rubber torsional element that absorbs shock and provides some forward propulsion.

Mauch Swing Phase Hydraulik™ Knee Unit (Mauch Laboratories, Inc.)
The Mauch Swing Phase Hydraulik™ Knee Unit provides resistance to swing control for both flexion and extension.

Mauch Swing and Stance (S-N-S) Knee Unit
The S-N-S Knee Unit provides weightbearing yielding resistance. It also provides stability in stumbling situations and allows easier descent of stairs and ramps.

Otto Bock Modular Single Axis Knee Joint
The Otto Bock Modular Single Axis Knee Joint is compact and uses an adjustable swing phase control that is very good for walking.

Terry Fox Running Prosthesis
The Terry Fox Running Prosthesis uses a Quadrilateral Suction Socket, DAW's Teh-Lin 4 Bas Pneumatic Knee, the Terry Fox Spring Shank with Otto Bock adapters, and the Greissinger 5-way foot.

SKIN CARE

Drionic Sweat Control System
The Drionic Sweat Control System is used on the residual limb to help control sweating.

Hood Socket Cleaning Kit
The Hood Socket Cleaning Kit is effective in reducing bacterial growth in hard sockets and also in those with soft liners.

IPOS Silicon Gel Sheet
The IPOS Silicon Gel Sheet can be fabricated into below-knee liners to assist in reducing shear forces on the skin.

Johnson & Johnson Bioclusive® Dressing
The Johnson & Johnson Bioclusive® Dressing is used on the residual limb to help heal a blister or to prevent one from developing. The 2 × 3 inch pad is the size most commonly used.

New Skin Cosmetic Treatment
When treated with New Skin, a prosthesis is completely waterproof.

Spenco™ 2nd Skin™
The Spenco™ 2nd Skin™ is a water-based gel that is used on the residual limb to treat a blister or to prevent one from developing. Paper tape, such as Johnson & Johnson's Micropore, is usually used to keep the dressing in place.

Spenco™ Skin Care Pad
Spenco™ Skin Care Pads can be applied to a stump, residual limb, or foot. It is attached with paper tape (e.g., Micropore). The 1/8 inch pads can be cut to size and used to cover blisters or in problem areas where blisters might occur.

SUSPENSION SYSTEM

ActivSleeve Suspension System
The ActivSleeve Suspension System produces a suction-type suspension. It allows the knee to pull out of the prosthesis and then go back into the socket without special adjustment.

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