Chapter 18

OCCUPATIONAL THERAPY FOR THE POLY-TRAUMA CASUALTY WITH LIMB LOSS

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INTRODUCTION

As stated by Dillingham "the care of amputees is a major problem facing any Army during wartime."[1] Historically, trauma experienced in battle results in substantial numbers of upper and lower extremity amputees that far exceed those seen in civilian medicine. For this reason, amputee care in the military must remain at the forefront of rehabilitation and technology while simultaneously maintaining readiness to assume the full care of treating service members (SMs) with limb loss.[1]

Since the beginning of Operation Enduring Freedom/Operation Iraqi Freedom, over 904 patients with major limb amputations have been managed in the military healthcare system.[2] The causes of injuries include mortars, gun munitions, improvised explosive devices, vehicle-borne improvised explosive devices, and rocket-propelled grenade launchers. Given the nature of these explosive and thermal injuries, the heavily contaminated wounds are left open to allow for multiple debridements and washouts in the operating room. Frequently, multiple extremities are involved and although injury patterns may be similar, no two patients are alike. As a result of the high force velocity and high temperatures at the time of injury concomitant injuries often occur. These range from traumatic brain injury (TBI) to visual loss, hearing loss, massive soft tissue loss, fractures, burns, and nerve and vascular damage. The severity and complexity of these polytrauma injuries in addition to amputation(s) complicate rehabilitation. Occupational therapy (OT) is critical in the treatment of patients with upper limb amputation. The focus of OT is on the patient's ability to engage in purposeful and meaningful activities. Human occupations may be work, leisure, or self-care related. Most occupations are performed with the hands and thus the role of the occupational therapist is to assist the amputee to perform these occupations with and without a prosthesis through the use of compensatory strategies or adaptive and durable medical equipment.

To address the rehabilitation needs of those individuals who have sustained complex polytrauma injuries in addition to upper limb amputation(s), a standardized, comprehensive, and multidimensional four-phase protocol of care was developed with a focus of achieving maximum reintegration into the community and resuming previous or assuming new occupational roles. The development of this protocol was most influenced by the *Model of Human Occupation* by Gary Kielhofner.[3] This theoretical framework facilitates understanding of the impairments, activity limitations, and participant restrictions resulting from limb loss, especially when accompanied by the comorbidities experienced by many patients.[3]

The *Model of Human Occupation* addresses the acquisition of preliminary and advanced performance skills, the underlying volition or motivation of patients required to engage in occupation, and the habituation required for use of the prosthesis while engaging in multiple roles and daily routines in their social and physical environments.[3] The goal of OT intervention for patients with limb loss is returning them to their potential for maximum performance of daily occupations that lead to a meaningful and satisfying life. OT provides the patient the necessary skills and tools to reintegrate back into the military unit or to civilian life physically, psychologically, and socially. Inherent in this overall goal is for SMs to successfully integrate the use of a prosthesis into their basic motor skill set if they so choose. The authors have termed the successful integration of the prosthesis as prosthetic acceptance or prosthetic integration.

The environments for amputee rehabilitation at the military amputee centers of excellence, such as Brooke Army Medical Center, Walter Reed Army Medical Center, and Naval Medical Center San Diego, are ideal settings because occupational therapists and prosthetists specializing in upper extremity amputee rehabilitation and prosthetics, respectively, are on site working jointly in the care and management of upper extremity amputees. Additionally, SMs stay on the campus of each facility while they undergo comprehensive rehabilitation and reintegration into the community with their prosthesis.

FOUR-PHASE UPPER LIMB AMPUTEE PROTOCOL OF CARE

As previously stated, the goal of OT intervention is for patients with limb loss to return to their highest potential for performance of daily occupations that lead them to a meaningful and satisfying life. To meet this objective a four-phase upper limb rehabilitation protocol is used. Phase one addresses initial management and protective healing; phase two marks the introduction of preprosthetic training; phase three addresses intermediate prosthetic training; and phase four focuses on advanced prosthetic training. Throughout each phase, discharge planning and community reintegration are incorporated and addressed to meet the patients' needs. Overlap occurs between each phase that is bidirectional to allow flexibility of patient progression based on severity of injuries, wound healing, and patient tolerance. The patient may regress in the protocol because of secondary problems of wound infection and delayed closure, heterotropic ossification, residual limb hypersensitivity, or other conditions resulting from concomitant injuries. Throughout each phase care is individualized to meet the needs of each patient, and as the patient becomes medically stable occupation-based goals are established. Also phases are repeated as necessary with each prosthesis that the patient acquires. With training of subsequent prosthetic use, the user's ability to master the foundational skills and perform functional tasks is rapid.

PHASE ONE: INITIAL MANAGEMENT AND PROTECTIVE HEALING

The primary overarching rehabilitation goals of this phase are to promote wound closure and educate the patient and family (Exhibit 18-1). This phase begins immediately after the injury and continues until all wounds have successfully closed and are free of infection. The time in this phase varies depending on the extent of the injury, but generally lasts from 1 to 3 weeks after admission. Patients and family members are introduced to rehabilitative and prosthetic services in the early stage of this phase. It is imperative that these interventions begin early to reduce uncertainties and fears, provide support throughout the grieving and recovery processes, and engage the patient and family with the rehabilitative team. The components of this phase include comprehensive evaluation, wound healing, edema control, desensitization and scar management, pain control, exercise, flexibility, gross motor activity, and psychological support. Basic activities of daily living (ADLs) include those activities that are involved in personal body care.[4]

Evaluation

A comprehensive evaluation of the patient is administered in a holistic and multidisciplinary approach to obtain baseline information about functional status, background, abilities, and future goals. This complete evaluation provides the rehabilitation team with a

EXHIBIT 18-1

PHASE ONE: BASIC REHABILITATION GOALS

Goals: 1 to 3 Weeks after Admission

1. All open wounds will be clean, dry, and free from infection.
2. Patient will perform self-feeding, oral hygiene, and toilet hygiene with the use of adaptive equipment and set up as necessary.
3. Patient will wear a form of compressive limb wrap 24 hours a day that extends above the most distal joint.
4. Patient will elevate the limb(s) as appropriate.
5. Patient will visually inspect residual limb.
6. Patient will tolerate tactile input on residual limb.
7. Patient will demonstrate independence in desensitization home exercise program.
8. Patient will tolerate scar massage.
9. Patient will assist in massage.
10. Patient will have functional active range of motion in bilateral extremities.
11. Patient will perform therapeutic exercise daily to prevent de-conditioning.
12. Patient will perform postural exercises with a focus on body symmetry.
13. Patient will receive support from the therapist through discussion of future function, which may include video of other prosthetic users.
14. Patient and the patient's family will receive information about the prosthetic rehabilitation process.
15. Patient and the patient's family will receive information about available types of prostheses and their differences.
16. Patient and the patient's family will receive information about the stages of grieving the loss of a limb and change in body image.

comprehensive assessment of the patient's physical and emotional baseline status.

The patient's medical history is obtained with special attention to all injuries that impact care and long-term goals. Current medications and the patient's response to these medications are documented. The evaluation includes an indepth information-gathering interview with the patient and family members to identify premorbid lifestyle and occupational roles, hand dominance, educational level, vocation, and recreational interests. Given the military's mobile nature, the patient's current living situation is reviewed to determine the level of family support available and any physical or environmental limitations within the current home environment that may be problematic once the patient returns home.

It is critical to screen each patient's psychosocial status. Information is gathered on the patient's current emotional state and his or her premorbid emotional resiliency. This helps the therapist to prepare for the next therapy session because it provides an understanding of where the patient came from and what he or she is going through emotionally. If possible, current knowledge, thoughts, and fears regarding amputation are also assessed. An understanding of the patient's previous exposure to amputees informs the therapist of the patient's possible perception of their injury. At the end of the evaluation, depending on the mental and emotional status and interest of the patient, a discussion is initiated regarding prosthetic rehabilitation and prosthetic options.

The objective components of the evaluation include the following:

- basic ADLs,
- upper quadrant range of motion (ROM) on the intact side,
- bilateral manual muscle testing,
- limb volume measurement,
- wound description,
- scar evaluation,
- pain (phantom and residual limb pain), and
- sensation of the residual and intact limb.

It is important for the therapist and prosthetist to assess residual limb sensation because areas of hyposensitivity or hypersensitivity are necessary considerations in the fabrication and fitting of the prosthetic socket. The evaluation includes a thorough assessment of pain of the residual limb, phantom pain, and its differentiation from phantom sensation.

A functional evaluation is completed to assess baseline basic ADL performance in bathing/showering, bowel and bladder management, toilet hygiene, upper and lower body dressing, personal hygiene and grooming, eating, sleep/rest, and functional transfers to include bed, chair, wheelchair, toilet, and shower transfers. Each area is assessed to determine the amount of physical and/or cognitive assistance that is required to complete the task. A rating of modified independent is given if the patient can complete the task with increased time or the use of adaptive equipment; a rating of supervision is given if the patient requires supervision to safely complete the task; a rating of minimal assistance is given if the patient requires contact guard-25% assistance to complete the task; moderate assistance if the patient requires 25% to 50% assistance; maximum assistance if the patient requires 50% to 75% assistance; and total assistance if the patient requires 75% to 100% assistance. All aspects of this ADL evaluation may be completed in one or several days depending on the patient's tolerance.

Prehension evaluations are performed as appropriate for each patient. Although no standardized evaluation for prehension deficits is identified in this population, it is necessary to determine baseline function of the remaining limb because the intact limb will be responsible for conducting all fine motor and dexterity tasks for vocational, leisure, and occupational purposes. Useful evaluations include the Jebson Taylor test of hand function; Minnesota Rate of Manipulation Test, Boxes and Blocks; and Nine Hole Peg tests.

Activities of Daily Living

The evaluation findings and assessment provide a foundation on which to build the treatment program. One of OT's major goals is to help the individual gain independence in self-care. This is a critical component that should be addressed very early when working with an amputee because a sense of dependence can lead to feelings of helplessness. This sense of helplessness is a common response after the loss of a limb; however, the degree of helplessness tends to be greater in the bilateral upper limb amputee. Therefore, it is essential for the rehabilitation team to assist the patient in gaining a sense of independence and control over his or her environment as soon as possible, preferably while still in the acute phase. Three ADLs that the occupational therapist should address in the first treatments include (1) toilet hygiene, (2) self-feeding, and (3) oral hygiene. These are some of the most rudimentary basic ADLs that can help the patient feel some sense of independence. Such adaptive equipment as toilet hygiene devices, use of foot-operated bidet, universal cuffs, and pump bottles can improve self-sufficiency in these tasks for the unilateral amputee.

Depending on the severity of injuries and medical stability of the patient, performance in additional basic ADLs may not be appropriate. Areas such as dressing, showering, and facial hygiene are addressed in phase two. However, if patients are medically stable and wounds are healed, phase two ADL training may be initiated earlier. Patients whose wounds and medical status do not allow progression to these ADLs are encouraged to wear loose-fitting pullover shirts, athletic shorts or pants, and slip-on shoes with traction on the sole to prevent falls. Adaptive equipment, such as a reacher and a dressing stick, is issued to patients as appropriate. Patients who are unable to use adaptive equipment require creativity on the part of the occupational therapist to achieve maximal independence in one-handed dressing strategies. See "Activities of Daily Living, Adaptive Equipment, and Change of Dominance" under phase two for some of these additional strategies.

Wound Healing

Wounds are left open for operative washouts and to avoid closed-space infections and tissue loss. Various procedures to promote healing are utilized depending on the type and size of the wound. If allograft soft tissue is used for skin coverage, drains are placed as appropriate. Wounds greater than 5 cm in depth are kept free from infection through intraoperative placement of antibiotic beads that are replaced surgically as necessary. Another strategy involves the use of vacuum-assisted closure systems, or negative pressure wound therapy. This technique is designed to promote the formation of granular tissue in the wound bed through intraoperative placement of sterile foam dressing with an evacuation tube placed over the dressing via an adhesive barrier creating an airtight seal around the wound. Negative pressure is applied by way of the evacuation tube, which is attached to an external canister to collect the wound exudate. The negative pressure therapy system is maintained until the wound enters the granulation stage and the wound edges draw closer together.

During initial residual limb wound healing, occupational therapists perform wound care and dressing changes according to physician guidelines. Also, a figure-of-eight wrap is used for distal to proximal compression and shaping over the healing distal aspect of the residual limb. Once the wound stops draining, the patient progresses to a sewn Compressogrip sleeve (AliMed, Dedham, Mass) or the use of Tubegrip (Valco Cincinnati Inc, Cincinnati, Ohio), which is tapered at the distal end of the residual limb. As the wound closes and the mature scar tissue forms, the patient and the family are instructed in the application and wear of a silicone liner that provides continuous force compression with the added benefit of minimizing hypertrophic scar tissue formation.

One of the goals for the patient, or his or her family member as appropriate, is to be able to independently don and doff compression garments. The compression garments are changed frequently throughout the day to maintain consistent concentric pressure from the distal to proximal margins of the residual limb. Edema control measures are implemented to assist in decreasing limb volume to prepare for fitting a preparatory prosthesis.

Desensitization

Desensitization is initiated promptly through the use of the aforementioned compression techniques. When the wound progresses to the granulation stage and drainage ceases, antibacterial ointment is applied to the wound bed for use with gentle massage and wound debridement, if necessary. As the wound closes, desensitization is initiated through tapping and the use of texture bins for immersion of the hypersensitive limb. Desensitization is critical and is performed daily as the patient's skin and scar tolerates. Reduction in residual limb hypersensitivity improves tolerance to wearing the prosthetic socket. Desensitization training is tailored for each patient depending on level of hypersensitivity and wound status. Patients and family members are also instructed in limb massage and desensitization to continue therapy outside of the clinic because this is critical for success.

Upper Limb Flexibility, Body Symmetry, and Exercise

The weeks immediately postamputation are the most critical in terms of implementing a comprehensive exercise program. The specific exercise program goals are established with physician guidance and coordinated between occupational, physical, and recreational therapies. The exercise program focuses on four main components: (1) flexibility, (2) body symmetry with exercise, (3) incorporation of the residual limb into activity to assist with desensitization and increase residual limb tolerance to pressure, and (4) muscle strengthening, the latter being addressed in phase two.

Daily maintenance of upper limb flexibility following amputation is critical to prepare the residual limb for prosthetic use. Initially, mat exercises should be utilized to promote independent upper limb mobility. Low load prolonged stretch to the shoulder flexors, abductors, and rotators as well as the scapular protractors and retractors is a priority because limitation of shoulder motion may result in rejection of the prosthesis.[5] The patient is then instructed to consistently increase the duration and daily frequency of the stretch. Each stretch should be performed for a minimum of five repetitions and held for 30 seconds in each joint direction. If self-stretches are not successful, then manual assisted stretching must be implemented with possible augmentation through facilitatory techniques. Good success has been achieved using proprioceptive neuromuscular facilitation techniques of contract-relax and slow-reversal for those patients demonstrating significant muscle guarding.[6] Pain medication, hydrotherapy, ultrasound, and other physical modalities may also be incorporated into the stretch program.

Incorrect postures may lead to cumulative trauma or overuse injuries of the upper limbs, neck, or back; therefore, emphasis is placed on proper body mechanics and awareness of body symmetry during activity. Visual feedback is the technique of choice for body symmetry awareness training and instruction often begins with observation of static postures in front of a mirror. Training quickly progresses to performance of dynamic therapeutic activities in front of a mirror. Additionally, the therapist provides verbal and tactile cues as necessary to maintain proper body symmetry. The patient is educated and encouraged to check his or her posture regularly when in front of a mirror during routine daily activities such as oral hygiene.

Patients with transradial level amputations or longer should be able to bear some weight directly through their residual limb. Early weight-bearing activities can reduce complaints of residual and phantom limb pain and prepare the residual limb for prosthetic usage.

Amputees must develop improved aerobic fitness levels because of the increased demands associated with prosthetic use. Exercise after limb loss is further enhanced through patient participation in physical therapy to address core strengthening and cardiovascular endurance (see Chapter 17, Physical Therapy for the Polytrauma Casualty With Limb Loss).

Pain Management Strategies throughout Rehabilitation

Amputee associated pain is broken into two distinct categories: (1) phantom limb pain and (2) residual limb pain. Phantom limb pain is described as pain in an absent limb or portion of a limb.[7] Residual limb pain is described as pain in the part of the limb remaining after the amputation.[8] These types of pain are acknowledged as two separate entities and have both common and unique treatment approaches for management.

Nonpharmacological pain management in the immediate postoperative period includes appropriate therapeutic interventions based on the type and origin of the pain. Treatment modalities include transcutaneous electrical nerve stimulation, ice, heat, contrast baths, massage, functional tasks to encourage normal motor pattern of the painful extremity, desensitization, and continuous psychological support in addition to psychiatric and pain management services. In some cases, an individual with a severely hypersensitive residual limb may benefit from desensitization 20 minutes five times per day until the sensitivity improves.[9] The use of a mirror box, in which the uninvolved side is visually reflected as the missing side, has been shown to decrease phantom pain in some cases.[10,11] Interventions for pain control are continuous through the multiple phases of the rehabilitation program.

Phantom sensation is any nonpainful sensory phenomenon in an absent limb.[7] Phantom sensation is frequently experienced after limb amputation and can be a concern to patients; therefore, it is important to reassure them that this is normal. The patient's experience of phantom limb sensation may change over time; research suggests that use of a prosthesis may improve phantom limb pain.[12,13]

Psychological Support

Psychological support is essential for successful rehabilitation and begins during the first interaction with the patient. Psychological support offered by OT during this phase encompasses patient and family education that facilitates coping and management of limb loss.

Psychological issues frequently seen in an amputee population include (*a*) fear of the unknown, (*b*) loss of self-esteem, (*c*) loss of self-confidence, (*d*) change in body image, (*e*) fear of rejection, and (*f*) loss of occupational roles. In the initial stage, patients are supported appropriately as their needs change. Intervention is provided by the entire interdisciplinary team. The goal is to successfully transition the patient to "real life" after hospitalization. Methods of psychological support include the following:

- education on the rehabilitative process to allay fears of the unknown,
- reinforcement of the patient's personal style,
- reassurance of normalcy of the patient's response to amputation,
- involvement in preventative medical psychiatry,
- engagement in empathetic interaction with both the patient and family,
- development of confidence and self-esteem,
- promotion of success in tasks and activities,
- encouragement to develop his or her identity, and
- engagement in weekly therapeutic outings.

PHASE TWO: PREPROSTHETIC TRAINING

Approximately 2 to 3 weeks after injury, depending on the patient's medical circumstances and concomitant injuries, he or she progresses into phase two of the protocol (Exhibit 18-2). The goal of this phase is to prepare the patient and the limb to receive a well-fit prosthetic socket and functional prosthesis. This phase begins at wound closure and ends with acquisition of a preparatory prosthesis, or an early postoperative prosthesis. Time spent in this phase varies depending on limb volume, sensitivity, ROM, physical condition of the residual limb, and the patient's psychological status. Therefore, portions of phase one continue as necessary to address these deficits.

Psychological Support through the Grieving Process to Acceptance

Patients entering the second phase may require additional psychological support from therapy as they progress emotionally from combat survival mode, through the awareness that they have survived a combat-related injury, to the realization that they will have to live with an altered body. Psychological support is continued and modified as necessary to appropriately respond to the patients' rapidly changing needs as they advance through the grieving process. As the patient demonstrates signs of acceptance of the injury, he or she is informed about the many

EXHIBIT 18-2

PHASE TWO: PREPROSTHETIC TRAINING: UNILATERAL AND BILATERAL AMPUTEE REHABILITATION GOALS

Rehabilitation Goals Specific to Unilateral Amputee

Goals: 1 to 4 Weeks after Admission

1. Patient will be independent in dressing using one-handed techniques.
2. Patient will be independent in light hygiene and showering with use of adaptive equipment as necessary.
3. Patient will be independent in donning compressive garment.
4. Patient will demonstrate in-hand manipulation without dropping items.
5. Patient will demonstrate functional prehensile patterns with an eating utensil.
6. Patient will demonstrate functional prehensile patterns with a writing utensil in the residual hand.
7. Patient will demonstrate proper position of body and paper for writing.
8. Patient will sign his or her name.
9. Patient will write a sentence.

Rehabilitation Goals Specific to Bilateral Amputee

Goals: 1 to 4 Weeks after Admission

1. Patient will receive adaptive equipment and technique training to maximize independence in self-feeding, oral hygiene, toileting, and dressing.

Common Unilateral and Bilateral Amputee Rehabilitation Goals

1. Patient will tolerate a compressive garment on the residual limbs 24 hours a day.
2. Once full range of motion is achieved, patient will tolerate a resistive upper body strengthening program.
3. Patient will be able to isolate two opposing myosites (ie, flexors and extensors).
4. Patient will be able to equally co-contract two opposing myosites.
5. Patient will tolerate myosite training daily.
6. Continue phase one goals as necessary (ie, scar management and desensitization).

possibilities of function with a prosthesis. Patients who choose to wear a prosthesis are educated on the reality of prosthetic function because individuals have varying perceptions of a prosthesis ranging from that of a picture of Captain Hook to the opposite extreme of a superhuman bionic arm. Adding peer support or a peer visitor significantly helps the patient. A peer support with a similar level of amputation can help educate about realistic expectations, provide a real life perspective of living with such an injury, and may potentially become a support with whom the patient can relate to throughout recovery. These peer visitors are trained individuals accessed through organizations such as the Amputee Coalition of America in Knoxville, Tennessee.

Patients may also participate in the Promoting Amputee Life Skills program, an 8-week course designed to teach persons with limb loss the skills to help them deal with problems they may encounter. The goals of the course are to reduce pain, depression, and anxiety, and to improve each person's ability to problem solve, communicate with family and friends, and improve overall quality of life.

Peak performance training, developed at the Center of Enhanced Performance at the US Military Academy, provides a method to effectively train individuals to develop mental and emotional attributes to efficiently operate in a fluid and ambiguous environment. The specific topics introduced include (*a*) confidence building, (*b*) goal setting, (*c*) attention control, (*d*) stress and energy management, and (*e*) visualization and imagery. Education and training to develop each skill is provided with the goal of the individual being able to ultimately achieve self-awareness, mental agility, and adaptability to overcome and thrive in demanding environments throughout recovery and future challenges.[14] This training may assist amputees to overcome the psychological hurdles throughout their emotional recovery and rehabilitation.[14]

It has been the experience of this rehabilitation team that the patient rapidly progresses through grieving during phase two. The supportive psychological services available, the therapeutic milieu, participation with other individuals with limb loss, and the performance of ADLs in an environment promoting recovery provide the basis to achieve psychological adjustment. Patients who successfully negotiate the grieving process frequently begin to verbalize or display their injury in a humorous light. For example, patients purchase and wear various clothing paraphernalia with sayings such as "dude where's my leg," or "IEDs suck." Although many of the statements are a crude representation of humor, they provide a valuable clinical sign that the individual has "broken through" the grieving process, entered the acceptance phase of recovery, and can project humor in regards to amputation.

Activities of Daily Living, Adaptive Equipment, and Change of Dominance

During phase two the patient becomes more independent with basic ADLs as the wounds heal. Independence in toileting, self-feeding, and oral hygiene is achieved during phase one, and the patient progresses to showering, dressing, personal hygiene, grooming, sexual activity, functional mobility, and laundry activities during phase two. The patient is introduced to various adaptive aids and compensatory techniques for one-handed ADL performance. Adaptive equipment offered includes (*a*) modified long-handled sponges, (*b*) one-handed nail clippers, (*c*) nail brush, (*d*) wash mitt, and (*e*) any other additional equipment necessary to achieve independence. In addition, custom adaptive equipment is fabricated as necessary for the patient to return to one-handed ADL independence. Data obtained through patient report revealed that the most helpful adaptive aids include the following:

- one-handed nail clipper and nail brush,
- modified long-handled sponges,
- elastic shoe laces,
- wash mitts,
- pump bottles,
- rocker knives or Knorks (Phantom Enterprises Inc, North Newton, Kans), and
- one-handed cutting boards.

Most patients prefer to minimize the number of adaptive aids because of the constrictions that equipment may pose for flexibility in task performance in different environments.

The bilateral upper limb amputee requires special attention to complete basic ADLs. Techniques and modifications listed in Table 18-1 (also shown in Figure 18-1) are basic ideas to assist the individual in achieving independence in ADLs. This table is not an exhaustive list. Once patients receive ADL training, they may continue to modify techniques and the environment to meet their individual needs. Many bilateral upper limb amputees become adept at using the environment, body movements, their mouths, and their lower extremities to assist themselves. However, significant use of the mouth is discouraged to prevent damage to the teeth and jaw. It is reasonable to expect that patients with bilateral transradial amputations will be independent with all ADLs and active in their chosen occupations. A patient with bilateral shoulder

TABLE 18-1

BILATERAL UPPER EXTREMITY ACTIVITY OF DAILY LIVING TASK SAMPLE TECHNIQUE OPTIONS AND CONSIDERATIONS

ADL Task	Sample Technique Options	Considerations
Toileting	• Use of a bidet. • Squatting down and using one's heel that is covered with toilet paper or hygienic wipes. • Placing toilet paper that is folded back on itself repeatedly on the toilet seat with the tail of the toilet paper dropped into the water to secure it.	• The prosthetic device must have wrist flexion and rotation if the prosthetic user is to perform toilet hygiene without other aids. This ability is patient dependent. • It is helpful for patients to try to develop a regular bowel program so that they can plan to be in a location where the environment is ideal for them to care for themselves. Otherwise it can be helpful to carry a supply of hygienic wipes when they are out in public.
Feeding	• Use of Dycem (Dycem Limited, Warwick Central Industrial Park, RI) or some nonskid material secures the plate or bowl and prevents sliding. • Use of a rocker knife or Knork (Phantom Enterprises Inc, North Newton, Kans) for cutting. When in a restaurant the person can ask for meat to be pre-cut before being brought to the table. • Use of a straw for liquids. • Use of a plate with a rim or a broad bowl to allow for ease in loading the utensil. • Some patients are comfortable bringing their mouth to the tabletop.	• A prosthesis that supports maximal elbow flexion, wrist rotation, and wrist flexion will allow patients to feed themselves with unmodified utensils. • Finger foods are often the most difficult due to the significant amount of ROM required to get to the mouth without the added length of the utensil.
Dressing	**Upper body dressing** • Pullover clothing should be placed at a higher height to allow patients to easily bend over and use their residual limbs in concert with their mouth to get the shirt over their limbs and head. At this point using body motion will assist in getting the shirt down over the torso. If patients have difficulty getting the shirt over their torso, have them lie down and maneuver on a bed. • Open-front shirts can be donned while hanging from a hook or hanger, again using the lower extremities to hold the tails of the shirt or the mouth to hold the collar to adjust the fit. • Jackets are donned easier if the cuffs are loose. • Buttons can be fastened using hook terminal devices or a button hook, or they can be modified by applying Velcro (Velcro USA Inc, Manchester, NH) closures. Buttons higher up at the neck are the most challenging. • Zippers can be more easily fastened with stable catches and a good pull tab or added string or monofilament line pull. • Pretied ties are the easiest to don.	• The patient with bilateral upper limb loss may find that loose-fitting clothing with limited fasteners will be easier to manage.

(**Table 18-1** *continues*)

Table 18-1 *continued*

ADL Task	Sample Technique Options	Considerations
	Lower body dressing • Garments with elastic waists will ease lower body dressing. Using a non-skid material like Dycem (Dycem Limited, Warwick Central Industrial Park, RI) mounted on the wall slightly below waist height can be used to assist in raising or lowering lower body garments. • Socks with loose cuffs that have been rolled down facilitate donning. Sock aids are useful to some patients. • Donning shoes is made easier by using slip-on shoes, Velcro (Velcro USA Inc, Manchester, NH) closures, elastic laces, or a variety of lace holders. • Preplacing a belt in the loops before donning pants makes donning a belt easier. • The hooks mounted on a donning stand or in a wall can be helpful for various aspects of dressing.	
Bathing	• Bathing may be performed by using elastic shower mitts over the end of the residual limb or by using a suction-mounted brush or scrubbing material. • Soap and shampoo can be applied from a wall-mounted soap dispenser or from pump dispenser type of bottles. • Drying oneself can be done easily with a terry cloth type of robe that hangs allowing ease of donning. • Drying can also be done with a wall or countertop-mounted hairdryer.	• It is critical to ensure a safe environment during bathing because a fall, when one does not have upper limbs to protect oneself, can be devastating. Using a nonskid mat in the tub provides secure footing in a slippery environment. Some patients may prefer to use a tub bench. A floor-to-ceiling pole can assist with getting in or out of a tub if a patient has one transradial length limb.
Hygiene	• Shaving is more easily performed with an electric shaver. A modified gooseneck with a clamp that is mounted to the wall can hold the shaver and be moved to access areas of the face (Figure 18-1). Women can sit and use a prosthetic device to shave their lower extremities. Women can consider laser hair removal, waxing, or electrolysis as an option for hair removal. • Brushing teeth can be performed with prosthetic devices or a mounted extension with a clamp. Using an electric toothbrush can facilitate better oral hygiene. • Trimming toenails can be done with a larger nail clipper mounted on a suction board. This can be operated with a prosthesis or the other foot depending on dexterity. • Use of a gooseneck arm with a clamp that is wall mounted can be useful to hold shavers, toothbrushes, and hair dryers. Commercially available hair dryer holders are helpful as well.	• Performing hygiene activities independently can be done with use of prosthetic devices, adaptive equipment, modifications to the environment, and use of many products made for the general public.

ADL: activity of daily living
ROM: range of motion

Figure 18-1. An example of a modified gooseneck clamp mounted to a wall. It provides a versatile method for a patient with bilateral limb loss to perform a variety of activities of daily living tasks independently.

disarticulation amputation will most likely require some assistance for certain ADLs despite the use of prosthetic devices and environmental modifications.

As a bilateral upper limb amputee becomes more independent in some basic ADLs, the learned skills necessary to achieve independence in these tasks will transfer when learning more complex daily living tasks. Initial training will require the therapist to be creative and the patient to be willing to try various approaches to a task to identify the best option. Once an ideal approach is identified repetition is necessary to habituate the new skill set into the motor repertoire to become more efficient in task performance. Additionally, learning more complex tasks will often occur with less frustration and more ease. Ultimately, each patient chooses the method(s) and equipment that work most effectively for him or her.

As mastery in basic ADLs is achieved the patient begins to explore instrumental ADLs, which are those activities that are complex and involve interaction with the physical and cognitive environment.[4] Instrumental ADLs addressed during phase two include the use of communication devices, light meal preparation and cleanup, financial management, mobility in the community, and safety and emergency response procedures. Depending on the patient's circumstances additional adaptive equipment recommendations are made in preparation for discharge.

In addition to progression toward instrumental ADLs, change of hand dominance training is introduced as necessary. Some patients perform this task with hesitation because they hope to use the prosthesis to perform writing tasks. However, based on the limitation of fine motor prehension and dexterity capabilities of any available prosthesis, it is important to transfer hand dominance for writing skills to reestablish independence in written communication. Fine motor activities include using tweezers, pumping spray bottles, twisting caps on and off, twisting nuts on and off of bolts, performing lacing activities on a vertical surface, and rolling putty balls. These activities encourage radial digit coordination, separation of radial and ulnar sides of the hand, and wrist extension. These are necessary motor components of handwriting. The patient learns rote penmanship exercises through progressive motor writing activities culminating in sentences with at least one character each from the alphabet: "The quick brown fox jumped over the lazy dogs." Bilateral upper limb amputees are encouraged to use a terminal device (TD) of their choice in order to gain the necessary skills for writing with a prosthesis.

At some point during the second phase of the protocol, most patients may be discharged from inpatient status, depending on medical status, comorbidities, and ability to perform self-care in a controlled living environment, such as a hotel on the military campus. This event marks a transition in the patient's recovery as he or she leaves the structure and safety of the hospital environment and is encouraged and successfully challenged to regain full independence. Evaluations similar to home evaluation are performed as necessary in this new living environment to ensure competence and confidence in ADL performance and reinforce the family members' caregiving responsibilities.

Postural Exercises and Strengthening

During phase two upper quadrant flexibility, postural exercises for body symmetry, residual limb weight bearing, and physical therapy are continued. Once the patient is medically stable and pain is controlled, early mobilization, general progressive strengthening and muscular endurance exercises are initiated with emphasis on the shoulder girdle and proximal residual limb to prevent joint contractures. Strengthening of the remaining upper limb musculature is aggressively pursued to prepare the patient for the weight and upper body strength demands of the donned prosthesis. Specificity of training is the preferred method to emphasize the remaining limb strength and function.

Strengthening exercises include isometric and isotonic contraction with modification to allow for use of the residual limb. Individuals who receive a body-powered prosthesis must strengthen the muscles that control shoulder flexion and scapular protraction, retraction, and depression because these gross body movements are used to control the prosthesis.

Rote practice of these movements early in rehabilitation will encourage muscle memory of those motions allowing for easier training once the patient receives the prosthesis.

The muscles that stabilize the gleno-humeral and scapulo-thoracic joints include the trapezius, serratus anterior, rotator cuff, and deltoid groups. These muscles play an important role in functional activity; therefore, a balance in muscle strength between these groups is critical to optimize prosthetic use. Scapular protraction, shoulder shrugging, and seated push-ups will help ensure proper scapular positioning for smooth gleno-humeral rhythm.[15] A spectrum of internal and external rotation up to 90 degrees in the scapular plane will maintain proper humeral head depression during shoulder elevation motions. Additionally, elbow stability should be maintained through bicep and tricep strengthening. Various therapeutic equipment and tools utilized for strengthening include Thera-Band and Baltimore Therapuetic Equipment (BTE Technologies, Hanover, Md). As the patient's endurance and residual limb tolerance to pressure improves, resisted exercises and weight-lifting activities involving the upper extremities should be considered. Trunk stability and core strengthening are also emphasized.

Myosite Testing and Training

Due to the rapid medical evacuation of an SM from the battlefield to the medical center, early and aggressive prosthetic rehabilitation is possible. For this reason, SMs are fitted with electric prosthetic systems that create less shear force and end-bearing forces on the healing residual limb. In instances where early prosthetic fitting is not possible, the residual limb may require further preparation for either a body-powered or electric prosthesis. Many SMs are fit with an activity-specific prosthesis that allows them to participate in meaningful leisure and recreational activities.

Research has demonstrated that individuals in the general amputee population fit with a prosthesis within 30 days of amputation exhibited a 93% rehabilitation success rate with a 100% return to work rate within 4 months of injury. Those fit beyond 30 days exhibited a 42% rehabilitation success rate with a 15% return to work rate within 6 to 24 months. This 30-day period is termed the "golden window."[16] The extensive polytrauma incurred during combat complicates the rehabilitation team's ability to achieve initial prosthetic fitting on combat-injured patients within this golden window. The impact of this problem has been managed through the use of training technology. Within 2 to 3 weeks postinjury, patients treated begin socket electrode site identification and training necessary for operation of a myoelectric prosthesis. The goals of this early intervention training are to identify, instruct, and train the patient to independently, correctly, and efficiently use specific residual limb musculature to activate and perform basic myoelectric prosthesis functions resulting in the ability to immediately operate the myoelectric prosthesis at first fitting.

Electrode site identification occurs in OT with use of socket electrodes (Figure 18-2) hooked up to a biofeedback unit, such as the MyoBoy (Otto Bock, Minneapolis, Minn), or the MyoLabII (Motion Control, Inc, Salt Lake City, Utah). Site selection involves multiple factors and requires the specialized skill of trained therapists and prosthetists to determine the proper and best available sites. The sites located in the training are used to identify the correct placement of the electrodes within the future prosthetic socket. The rehabilitation team works closely together during this stage to identify the best possible electrode placement and the most effective control scheme for each patient's particular abilities and needs.

Many factors affect the optimal muscle site selection. Ideally a flexor muscle—used to operate TD closing and pronation—and an extensor muscle—used to operate TD opening and supination—are identified. However, many patients do not have two available sites or have undergone reconstruction resulting in nonanatomic tissue presentation of the residual limb. These cases require team creativity and individual encouragement. Other issues to consider include (*a*) scar and graft site locations because the signal is not as easily transmitted through dense tissue, (*b*) identification of an appropriate superficial muscle site for a stronger signal, and (*c*) continuous contact between the skin and electrode at the selected myosite throughout the maximum ROM of the residual limb. The latter requires special attention during this process. For

Figure 18-2. Socket electrode used for myoelectric training. This same type of electrode is placed within the myoelectric prosthetic socket.
Photograph courtesy of Otto Bock.

example, if an electrode is placed over a proximal residual limb muscle that is activated during an activity such as reaching, the individual will perform inadvertent operation of the prosthesis and experience frustration. A quality muscle signal is characterized by an adequate electromyogram output that is isolated from the antagonist muscle. Once the best sites are identified, motor training begins.

Motor training takes place using computer-based MyoSoft software attached to the MyoBoy hardware (Otto Bock, Minneapolis, Minn) and the socket electrodes. On an electromyogram-like screen, the patient can visualize color-coded signals, representative of each of the selected electrode site muscles, as they are activated for the corresponding TD operation (Figure 18-3). Initially, the focus of training is on independent activation of each muscle. When the patient is able to demonstrate separation of these muscle signals, the concept of proportional control is introduced. Proportional control is a term used to describe the proportional relationship of the elicited strength of the selected muscle contraction to the speed and grip force of the TD. Many myoelectric components use this type of control. It is more physiologic and predictable for the patient than previously used digital control systems. Depending on the manufacturer of the system, the gain (sensitive) of the electrodes may be manually adjusted. This allows the therapist to amplify or dampen the strength of the received signal from the muscle contraction to modulate prosthetic output. Changes in the gain may need to be made frequently as the individual develops mastery of control and increased muscle strength.

The initial myosite training takes place with the upper limb in a relaxed position at or near midline. As the patient develops control in this plane, introduction of limb placement in various positions is initiated to

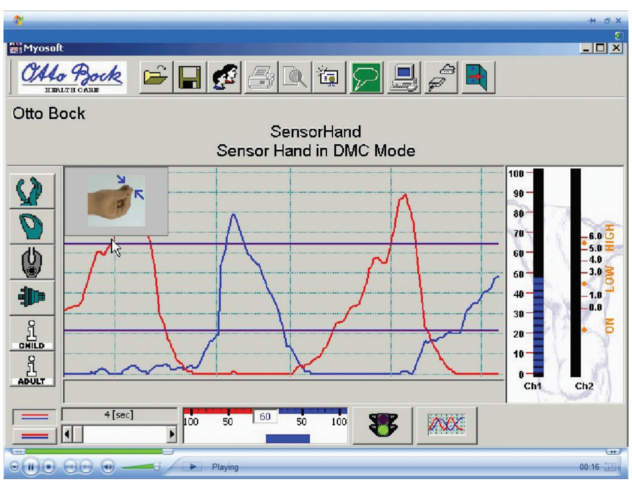

Figure 18-3. MyoBoy software (Otto Bock, Minneapolis, Minn) computer screenshot demonstrating a patient performing signal separation. For example, signal 1 (blue line) represents the flexor muscle or the muscles identified to most commonly perform terminal device closing and pronation; signal 2 (red line) represents the extensor muscles or the muscles identified to most commonly perform terminal opening and supination. The goal is for the patient to be able to activate each muscle signal (1 and 2) separately without co-contracting the other muscle (1 or 2).
Courtesy of Otto Bock.

a

b

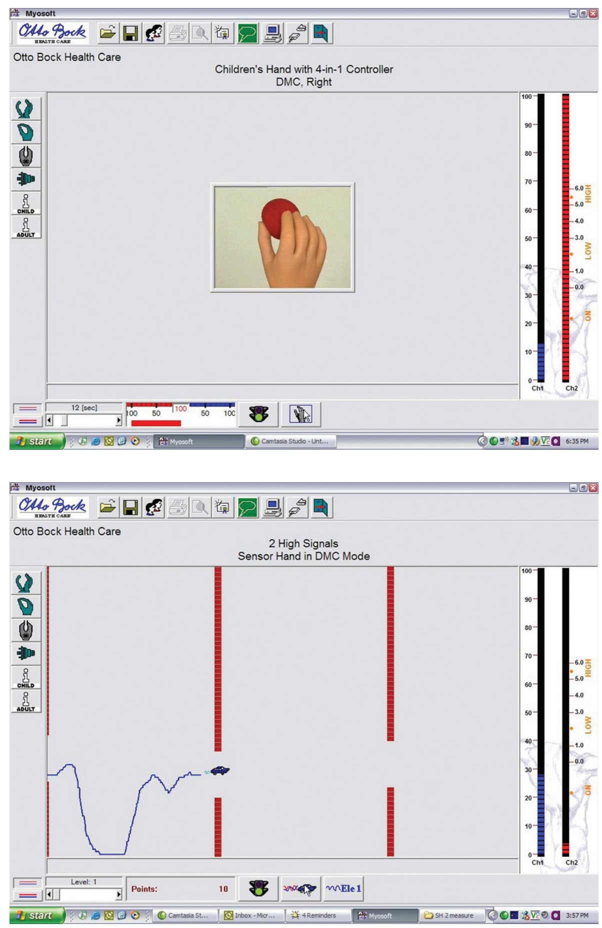

Figure 18-4. Various games are available on the MyoBoy software (Otto Bock, Minneapolis, Minn) package. **(a)** The object of the virtual hand game is for the patient to exercise the proper force of contraction to grasp and release the ball. **(b)** In this example, the car represents one of the two muscle signals used to control the terminal device. The object of this game is for the patient to master accuracy with contraction force and to increase contraction endurance to navigate the car over the wall without crashing. This game can be further graded with the addition of a second simultaneous car representing the opposing muscle used for terminal device operation.

simulate reaching to heights, across midline, and to the floor. Use of an isolated muscle in such a way, especially following major trauma, is foreign and fatiguing; therefore, the individual's endurance should be considered during initial training. The MyoSoft offers programs with a virtual hand that respond to muscle signal as a myoelectric TD would and a car game that uses accuracy and a score for the competitive at heart (Figure 18-4). The excitement of success and the involvement of competition in the training process are contagious, but must be monitored to prevent fatigue and subsequent overuse.

The electrodes used for the myosite training can be attached to the patient's actual TD before fabrication of the early postoperative prosthesis (Figure 18-5). This step provides a three-dimensional perception of the prosthesis. The concepts of pre-positioning for the most efficient grasp patterns with different shapes of objects and appropriate force control with different densities of objects are effectively introduced during this stage.

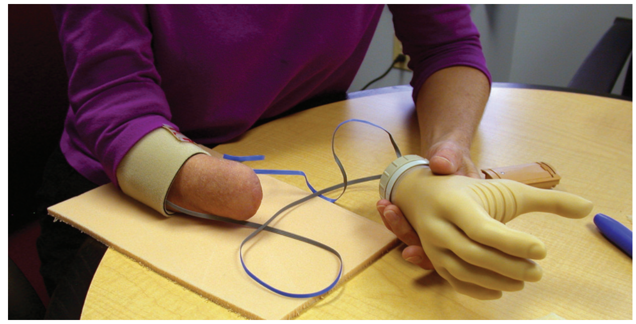

Figure 18-5. The socket electrodes attached to the actual terminal device are placed on the corresponding myosites. The patient is instructed to activate each muscle to perform the specified terminal device function. This approach provides three-dimensional, real-time feedback to the patient.

The skills and knowledge that the patient gains during the preprosthetic training phase are critical to continued motivation and success with his or her prosthesis. Patients that receive preprosthetic training demonstrate some initial success at first fitting. This phase promotes motivation, gain of function in the residual limb, and a preliminary sense that the patient will once again have control over his/her life. The earlier the individual learns these valuable principles, the easier it is to transition to actual prosthetic use and refrain from poor ergonomic postures during prosthetic use that may lead to cumulative trauma disorders. For those individuals with limited muscle site access or injury-related denervation, other options are available. The use of one site to control mechanisms can be explored or the use of nonmyoelectric tension control systems can be very useful.

PHASE THREE: INTERMEDIATE PROSTHETIC TRAINING

Rehabilitation of the upper limb amputee is complex for three primary reasons. First, the human mind is powerful and it quickly retrains the body to accomplish daily life tasks such as cooking, eating, bathing, grooming, and toileting with the use of only one hand and occasionally adaptive equipment. Second, unlike the lower extremity that serves a purpose for propulsion during walking and balance during standing, the upper limb is extremely complex in its many functional operations at multiple joints and requires many integrated motions to accomplish preferred occupational tasks. Third, by comparison to the human limb, current prosthetic systems are heavy, bulky, and uncomfortable, and they require unfamiliar motor pattern performance to produce a simulated function that is rudimentary. Overall, it is a challenge to return an upper limb amputee, who quickly adapts to one-handed living, to a contrived two-handed world with one intact limb and one artificial limb.

A valid question often posed by the upper limb amputee, especially younger ones, is "Why do I have to wear a prosthesis?" As previously mentioned, it is true that most unilateral amputees can function independently with the use of one hand. The prosthesis will never truly replace the loss of a human limb. Instead, a prosthesis is a primitive facsimile of the original arm, which can be clumsy and uncomfortable and feel foreign to the wearer. However, with early, skilled prosthetic training the improvement in independent functional performance cannot be understated.

Phase three marks a major turning point in the rehabilitative care of the upper limb amputee. Phases one and two lay the foundation for success in phase three. Phase one and two wound healing, strengthening/endurance training, desensitization, residual limb shaping, and myosite testing and training provide the foundation for actual practice and prosthesis use. The focus during phase three is for the patient to master and habituate the mechanical actions required for prosthetic limb control, integrate prosthesis use in activity performance, and ultimately achieve independence in all purposeful and meaningful daily life activities. The goals of phase three training include (*a*) knowledge on the operation and performance of the prosthesis, (*b*) initiation of controls training, and (*c*) initiation of ADL training (Exhibit 18-3).

EXHIBIT 18-3

PHASE THREE: INTERMEDIATE PROSTHETIC TRAINING: UNILATERAL AND BILATERAL AMPUTEE GOALS FOR MYOELECTRIC AND BODY-POWERED PROSTHESIS

Unilateral Goals: 2 to 8 Weeks after Receiving Prosthesis
Bilateral Goals: 4 to 10 Weeks after Receiving Prosthesis

Common Unilateral and Bilateral Transradial and Transhumeral Amputee Rehabilitation Goals

1. Patient will be independent donning and doffing select prosthesis (M, B).
2. Patient will know, understand, and demonstrate compliance with the prosthetic wear schedule as directed by therapist (M, B).
3. Patient will independently perform limb hygiene daily (M, B).
4. Patient will be able to perform basic care of the prosthesis (M, B).
5. Patient will progress to tolerate prosthetic wear 6 to 8 hours per day (M, B).
6. Patient will be able to change the cable system (B).
7. Patient will be able to adjust the harnessing system (B).
8. Patient will be able to identify components and understand terminology of select prosthesis (M, B).
9. Patient will be able to change the TD independently (M, B).
10. Patient will be able to open and close the TD through the full range (M, B).
11. Patient will be able to open and close the TD to 1/3, 1/2, and 3/4 ranges (M, B).
12. Patient will be able to operate the wrist flexion component if applicable (M, B).
13. Patient will be able to operate the wrist rotation unit (M, B).
14. Patient will be independent in the battery change and charge process (M).
15. Patient pre-positions TD without verbal cueing (M, B).
16. Patient will become modified independent, using prosthesis, in basic ADLs within a reasonable time period with minimal extraneous movement and energy expenditure (M, B).

Specific Elbow Disarticulation and Transhumeral Rehabilitation Goals *(in addition to goals 1 - 16)*

1. Patient will demonstrate locking/unlocking of the elbow unit (M, B).
2. Patient will be able to position the elbow at 1/3, 1/2, and 3/4 range with and without weight (M, B).
3. Patient will demonstrate free swing if available (M, B).
4. Patient will demonstrate simultaneous control of the elbow unit and the TD concurrently (M).
5. Patient will position turn table component for internal/external rotation (B).
6. Patient pre-positions elbow unit without verbal cueing (M, B).

Specific Shoulder Disarticulation or Scapulo-thoracic Rehabilitation Goals *(in addition to goals 1 - 16, and Elbow Disarticulation and Transhumeral Goals)*

1. Patient will demonstrate unlocking/locking of the shoulder unit (M, B).
2. Patient will demonstrate free swing of the shoulder unit (M, B).
3. Patient pre-positions shoulder unit without verbal cueing (M, B).

Common Advanced Control Training Goals for Unilateral and Bilateral, Transradial, and Transhumeral Amputee *(Initiate once all above goals have been achieved)*

1. Patient will demonstrate simultaneous control of the TD concurrent with elbow unit operations (and shoulder unit if applicable) (M, B).
2. Patient will demonstrate proficiency in grasping and releasing objects in various planes away from midline (M, B).
3. Patient will demonstrate proficiency in proportional control when grasping objects without crushing (M, B).

(**Exhibit 18-3** *continues*)

Exhibit 18-3 *continued*

Additional Bilateral Advanced Control Training Goals ***(in addition to common goals 1 - 3)***

1. Patient will be able to operate one prosthesis without inadvertently operating the other prosthesis.
2. Patient will be able to operate prostheses simultaneously or in isolation.

ADLs: activities of daily living
B: body-powered
M: myoelectric
TD: terminal device

Operational Prosthetic Knowledge and Performance

Initially, most patients receive a myoelectric prosthesis. However, in some instances fabrication of a body-powered prosthesis may be prescribed. A body-powered prosthesis, also known as a conventional or cable-driven prosthesis, is powered by the patient's own body motions. Depending on the amputation level more cables are attached for control from the prosthetic harness system to the TD and if necessary the elbow joint. Gross muscle movements of the residual limb, shoulder, scapula, and chest are captured by the prosthetic harness system, and the force produced through these motions generates tension on the cable(s) affording prosthetic use.

There are two main types of prehensile TD systems available for body-powered systems: (1) voluntary open and (2) voluntary close. In the voluntary open system, the TD remains in the closed position until the user exerts specific gross body motions to open the TD. The force to sustain prehensile grasp is produced by elastic bands or springs on or in the TD. With the voluntary close system, the TD remains open until the user produces gross body movements to close the TD around an object. Springs within the TD provide the force to sustain grip in this system.

As previously mentioned, ROM and upper body strengthening of the intact proximal muscle groups improve the overall condition of the upper body and aid the prosthetic user in achieving full functional use of his or her prosthesis without the need for additional prosthetic and environmental modifications. The gross body movements used to control the body-powered prosthesis include (*a*) shoulder flexion, abduction, and extension; (*b*) scapular protraction, retraction, and depression; and (*c*) chest expansion.[17-19]

Scapular Protraction, Retraction, and Shoulder Flexion

Opening and closing of the body-powered TD is controlled primarily through shoulder and scapular movements depending on the type of TD system. Protraction (or retraction in a voluntary open system) of one or both shoulder blades and forward flexion of the residual limb causes the contralateral side to stabilize the harness at the axilla and shoulder, thereby producing tension across the control cable, which is attached between the harness and TD. In a voluntary open system, scapular protraction will cause the TD to open and scapular relaxation/retraction will cause the TD to close. In a voluntary close system, scapular protraction will cause the TD to close and relaxation/retraction of the scapula will cause the TD to open. Forward flexion is also used to flex and extend the forearm of an above elbow prosthesis when the elbow is in unlocked position.[17-19]

Scapular Depression and Shoulder Extension and Abduction

Unlocking and locking of the elbow for an above elbow prosthesis is controlled through scapular depression and shoulder extension and abduction. The combination of the movements lengthens the attachment between the harness and elbow unit and in turn activates the locking mechanism of the elbow. When the elbow is unlocked the forearm can be controlled through shoulder movements.[17-19]

Chest Expansion

Although this motion provides less excursion force than shoulder and scapular movements, chest expansion can be helpful to provide improved prosthetic control to patients with high-level amputations, nerve involvement, or other comorbid injuries. Modifications in harness design may be needed to capture this motion.[17-19]

Regardless of the type of prosthesis, it is critical that the individual obtain and demonstrate knowledge of component terminology, a general understanding of how the components make up the prosthesis, and instructions on how to perform basic maintenance on the prosthesis. This education affords the patient a basic vocabulary to effectively articulate with the rehabilitation team any mechanical difficulties or operational malfunctions of the prosthesis. Ability to articulate malfunctions using correct terminology greatly assists the prosthetist in diagnosing and fixing any repair issues. The prosthetist provides equipment education and reinforces it during therapy. Each patient should possess common terminology including—but not limited to—the following:

- socket and harnessing design,
- component terminology care,
- types of TD(s),
- type of control system(s) used, and
- basic mechanics of the prosthesis.

The patient must communicate with the prosthetist when maintenance is required. When basic repairs are necessary, the goal is for the patient to have enough knowledge to perform such maintenance. The patient is expected to be able to perform the following:

- socket maintenance to include daily cleaning and inspection of the socket;
- battery charging and component maintenance to include routine cleaning and application of lubricant; and
- harness adjustment, rubber band replacement, and cable system changes, as needed.

Patients are provided with this education for use in settings where a prosthetist may not be available. The occupational therapist is responsible for ensuring that patients receive ample functional training to make them efficient and proficient in functional maintenance performance and prosthetic care in various environmental and physical circumstances relative to their everyday operational environment. Also, the occupational therapist is responsible for considering any other existing injuries that may hinder efficient performance of maintenance tasks and identifying ways for the patient to perform these tasks independently. For example, a patient that wants to return to the theater of operation would practice—while participating in OT—prosthetic maintenance under simulated conditions to mimic such an environment.

Residual Limb Tolerance/Care

With traumatic amputation, the limb continues to heal beneath the surface of the skin well beyond wound closure and that makes the limb more susceptible to pathology. Frequent inspection of the residual limb(s) should become a daily ritual for all prosthetic users. If the skin integrity of the residual limb is compromised the patient's ability to wear the prosthesis is hindered. Buried fragments, development of heterotropic ossification, peripheral nerve injuries, or the development of a neuroma are several type of injuries that may make the residual limb more susceptible to skin disruption. The rehabilitation team should inform the patient about the signs and symptoms of potential significant changes related to these areas.

Along with inspection of the residual limb, establishing a wearing schedule for the prosthesis is also important. Initially the prosthesis should be worn for no more than 15 to 30 minutes, 2 to 3 times daily. Upon doffing of the prosthesis, the residual limb should be thoroughly inspected for any skin redness, irritation, and breakdown. If no signs of ill fit are evident, the user can increase the wearing time by 30-minute increments, 2 to 3 times daily. Improper socket fit must be immediately addressed by the prosthetist. Inspection of the residual limb should continue to be a daily routine even after the patient has progressed to all-day wear and use of the prosthesis. Along with limb inspection, proper hygiene of the residual limb is also essential. This includes daily washing of the residual limb with mild soap followed by thorough drying before donning the prosthesis.

Donning/Doffing Prosthesis

The eventual goal is for the prosthetic user to be able to tolerate approximately 8 hours of prosthesis wear and use within 1 to 2 weeks from the start of training. Therefore, early independence in donning and doffing is important to achieve. The patient must be able to independently don and doff the full prosthetic system that includes (*a*) residual limb sock, (*b*) prosthetic donning liner, (*c*) prosthetic socket, and (*d*) harnessing(s) as appropriate.

There is a range of different methods for donning/doffing each type of prosthesis. When training the patient on donning and doffing the myoelectric prosthesis, the Reduced Friction Donning System (Advanced Arm Dynamics, Inc, Redondo Beach, Calif) is used (Figure 18-6). With the use of a special donning sock and socket design, the limb is placed into the socket and the sock is pulled out of the socket. The result is secure soft tissue placement within the socket trim lines ensuring optimum electrode contact. Individuals with a transhumeral amputation use the same donning system for application of the myoelectric prosthesis. However, on the socket a prosthetic valve is added to create a suction or semisuction fit of the socket on the limb. Once the sock is removed from the socket the excess air is removed at the touch of a button allowing for a vacuum seal. In the transradial socket, valves are

a b c d

e

Figure 18-6. The patient is trained to don the myoelectric prosthesis with the use of a limited friction donning sock with a lanyard secured to the end. (**a**) The sleeve is inverted over the residual limb. (**b**) The lanyard is dropped through a pull tube that is located in the distal end of the socket. (**c**) The sock-covered limb is placed in the prosthesis. The patient places tension on the lanyard to begin to pull the sock through the socket, thus pulling the limb into the socket. (**d**) Additional tension to pull the sock is achieved by placing the loop of the lanyard around the foot and subsequently pulling the sock out of the socket while the residual limb provides counterforce to the prosthetic socket. (**e**) The sock is pulled through the tube via the lanyard gently bringing the soft tissue into the socket.

rarely used because the sockets are typically suspending via bony anatomy.

When training to don the body-powered prosthesis the patient is instructed in the pullover method, where the harness is donned over the head, or the jacket method, where the harness is donned over one extremity and then the other (Figure 18-7 and Figure 18-8). The methods for donning and doffing the prosthetic system for bilateral amputees vary significantly based on level of amputation. However, the end goal is for the patient to perform this task independently. Additional creativity on the part of the therapist and patient is required to achieve this goal. Sample technique options for donning and doffing the prosthesis are listed in Table 18-2 and Figure 18-9. All patients are informed about the most appropriate method for them and they may even develop their own technique.

Initiation of Controls Training

Learning to use any type of prosthesis is similar to learning the operation of other multicomponent mechanical devices. For example, when beginning to drive, the first step is learning to control the individual components required for operating a vehicle. This includes turning it on and off; adjusting the mirrors and seats; and operating the gear shift, gas, and brake. These components are eventually combined into the actual performance of driving a vehicle. Similarly, when an amputee begins his or her prosthetic training, the first step is to learn how to control the individual components to operate the prosthesis. Subsequent steps in the newly learned motor patterns are combined to accomplish tasks creating a hierarchy of progression through the controls training. The goal is to achieve smooth movement of the prosthesis with minimal amount of delays and awkward motions in daily activity task performance.[20]

The tasks used to achieve mastery of each control skill depend on the therapist's creativity. Media appropriate for training include objects of various shape, texture, density, and weight, such as 1-inch wood square blocks, round blocks, cotton balls, Styrofoam cups, or a cup filled with water. This type of media provides various different ways to grade the task at hand to achieve mastery of control. Initial training is frequently rote. However, with mastery of each skill, motions are combined resulting in performance of an activity. A multisensory approach is also useful. Verbal, tactile, and visual cues can be helpful to attain success. The progression through the hierarchy of body-powered and myoelectric prosthetic controls training described by each level of upper limb amputation is depicted in Figure 18-10 and Figure 18-11, respectively.

Patients performing controls training with the use of a preliminary myoelectric prosthesis may find that the gains of the imbedded electrodes require adjustment to perform the task at hand. The prosthetist can more specifically set the electrode sensitivity with customizing software that is specific to each manufacture.

Activities of Daily Living Prosthetic Training

The final stage of phase three is to apply the skills learned during the controls training portion to begin functional use of the prosthesis. The user may become

Figure 18-7. Sample donning methods for a transradial amputee with a body-powered pin lock suspension prosthetic system. (**a**) The roll on silicon liner is inverted and rolled onto the residual limb. (**b**) The residual limb is placed through the harness (note the locking pin at the distal end of the liner). (**c**) The limb is guided into the socket with slight pressure to secure the pin into the pin lock within the socket. This creates a secure relationship between the patient and the prosthesis to allow for more aggressive activities or for reduced harnessing. This type of suspension has been found to be necessary for the activity level in this population. (**d**) Instructing in the jacket method of donning, the harness is pulled across the back and the residual limb is placed through the remaining figure-of-eight harness. (**e**) Instructing in the over the head method, the residual limb is placed through the figure-of-eight harness anteriorly before guiding the harness overhead. (**f)** The completed figure-of-eight body-powered prosthetic system is donned. It is important that the patient adjust the placement of the figure-of-eight ring when donning this system to ensure the harness is centered both medially and laterally and distally and proximally between the scapulae.

a

b

c

Figure 18-8. Sample donning method for a transhumeral amputee. (**a**) Preparation for donning a suction socket prosthesis using the jacket method, the elbow is locked into 90 degrees flexion and the prosthesis is laid out with the harness system toward the outside of the body. (**b**) The residual limb is placed into the socket using downward force with the prosthesis stabilized using the remaining limb. (**c**) The harness is donned across the back and under the residual arm. The harness is secured to the anterior portion of prosthesis with snaps, buckles, or Velcro (Velcro USA Inc, Manchester, NH).

more frustrated because of the awkward and artificial nature of a prosthesis. In addition, those with unilateral amputation quickly learn to adapt to one-handed task performance that can become habitual. The rehabilitation team must continue to provide support and encouragement during basic daily living skills to help the individual use a prosthesis.

Rating guides developed by Atkins titled "Unilateral Upper Extremity Amputation: Activities of Daily Living Assessment" (Figure 18-12) provide a comprehensive list of activities the patient should be able to perform with the use of the prosthesis.[20] A rating guide is also available for bilateral upper limb amputations. The patient is observed performing the identified tasks and is graded on task performance using a zero to three scale; zero identifies tasks that are impossible for the individual to complete; one identifies tasks that are accomplished with much strain or many awkward motions; two identifies tasks that are somewhat labored, or few awkward motions; and three identifies tasks that are performed smoothly, with minimal amount of delays or awkward motions. With the permission of Diane Atkins through direct communication, these rating guides were modified to include tasks relevant to military duties. It is unreasonable to expect a unilateral amputee to use a prosthesis to the same extent because he or she spontaneously uses the preexisting sound limb.

The level of difficulty in training and the amount of training time needed may vary from one prosthetic user to another. Factors that may influence this include the level of amputation (ie, transhumeral vs transradial), unilateral versus bilateral amputation, and the type of prosthetic device fitted to the user (ie, body-powered vs myoelectric prosthesis). Additional

TABLE 18-2

BILATERAL UPPER EXTREMITY PROSTHETIC SAMPLE DONNING AND DOFFING STRATEGIES AND CONSIDERATIONS

Strategies	Body Powered	Myoelectric	Considerations
Donning prostheses: This will be dependent on the type of prostheses and the harnessing system used. Donning methods vary based on the suspension system and whether the prosthetic devices are harnessed independently or connected through harnessing.	• If each prosthesis has an independent harness system, the longer of the residual limbs is donned first. This prosthesis is then used to assist with donning the second prosthesis. • If the prostheses are connected by harnessing, the shorter residual limb prosthesis will be donned first. The two most common methods of donning attached prostheses is to don the prostheses as you would a coat or to place both limbs simultaneously in the prostheses and don them overhead like a T-shirt.	• Self-suspending sockets are often donned using a reduced friction donning sock. The patient will use the lower extremities or the other prosthesis to pull the sock through the pull tube that pulls the soft tissue into the socket providing an intimate fit with skin traction. • Suction sockets are donned using an evaporative moisture technique, such as Cal Stat (Steris Corporation, Mentor, Ohio), or other products. Air is expelled through the valve as the limb is pushed into the socket creating a suction fit.	• A donning stand may be helpful for high-level amputee patients (Figure 18-9). Additionally, patients with high-level amputations will require more creativity from the prosthetic team for independence in donning.
Doffing prostheses: Doffing is often easier than donning.	• If the prosthesis is donned using the jacket or T-shirt method, the prosthesis is doffed using the method in reverse.	• To doff a self-suspending type of prosthesis, patients will typically use their lower extremities or the environment to assist in removing the prosthesis. In the case of a suction suspension, patients will often use an object in their environment to assist them to press the button on the valve that will release the suction. The donning stand can also be used as needed.	

factors include the individual's (*a*) motivation, (*b*) cognitive and emotional status, and (*c*) physical condition and comorbid conditions. The ultimate goal is for the patient to achieve maximum independence in the performance of ADLs and instrumental ADLs through the integration and use of the prosthesis.

Although using a prosthesis to perform ADLs is supported, patients are also encouraged to master independence in one-handed ADLs because there will be times when the prosthesis is unavailable. The patient must master one-handed ADL performance independently, efficiently, and ergonomically correctly to avoid the possibility of developing cumulative trauma disorders. The patient is taught the signs and symptoms of various cumulative trauma disorders and encouraged to seek initial medical attention early if they develop. Little information has been published on the prevalence of over-use injuries in the upper limb amputee population; however, a small study published by Jones and Davidson found over-use injuries were more common in the unilateral amputee population than the nonamputee population.[21]

Muscle Strengthening and Endurance

The patient should be independent with a postoperative self-stretching program of the same frequency and duration as previously discussed. The patient can incorporate the prosthesis into the stretching program. The therapist emphasizes strict adherence to this program because many patients neglect joint stretching once they begin to reach their goal of ADL independence. However, the patient remains at risk for shoulder and elbow contractures because scar and surgical incisions continue to mature.

Muscle endurance training and strengthening require a more demanding, yet specific mode. The patient continues to participate in a regular cardiovascular program with physical therapy and is encouraged to incorporate the use of the prosthesis during such physical activity. Supervised progressive strengthening is initiated through weight training. Programs begin conservatively for 15 to 20 minutes at low resistance with minimal distal end weight bearing of the residual limb. There is no published set protocol for progressing resistance training for the upper limb amputee. Skin and residual limb tolerance are the confounding factors when progressive upper limb conditioning is initiated. During weight training the patient must have a properly fitting socket with adequate suspension and a TD that will allow completion of the weight-lifting task. A snug prosthesis will increase total surface area contact and thus reduce the incidence of skin trauma from shearing or abnormal forces. Weight lifting may not be well tolerated in the transradial amputee or the amputee with a self-suspending socket because abnormal leverage or the traction of tissues, respectively, coupled with the need for full elbow extension as part of an exercise may increase socket pressure in the antecubital region or the condyles. A safety point as weight lifting increases is to secure the weight to the TD.

Figure 18-9. An example of a donning stand that may allow a patient with bilateral upper extremity limb loss independence in the donning and doffing of a body-powered prosthesis.

PHASE FOUR: ADVANCED PROSTHETIC TRAINING

Phase four begins approximately 8 to 16 weeks after the initiation of rehabilitation (Exhibit 18-4). This time frame is not fixed, however, and it depends on the patient's medical and rehabilitation progress. Individuals who reach this stage can accomplish all basic skills from phase three. They can don and doff the prosthesis independently, tolerate a full day's wearing schedule, and are proficient in basic operations of the prosthesis. The goals of this phase are for the patient to complete basic and advanced daily tasks incorporating the prosthesis efficiently and demonstrating a natural motor pattern. The outcome of this phase is for the patient to save body energy, decrease biomechanical stress to the intact limb, and learn the best approach to tasks without extraneous body movements and the reliance on adaptive equipment.

Five characteristics of advanced prosthetic rehabilitation are available to guide therapists during this phase. The first characteristic is that advanced rehabilitation is highly individualized. Overall, successful rehabilitation of upper limb amputees involves knowing the whole person and what meaningful occupations they previously selected; however, phases one, two, and three follow more of a predictable therapy guide to treatment activities. When the patient progresses to phase four, therapy becomes more individualized, incorporating his or her particular vocational and avocational goals. The second characteristic is that this phase most as-

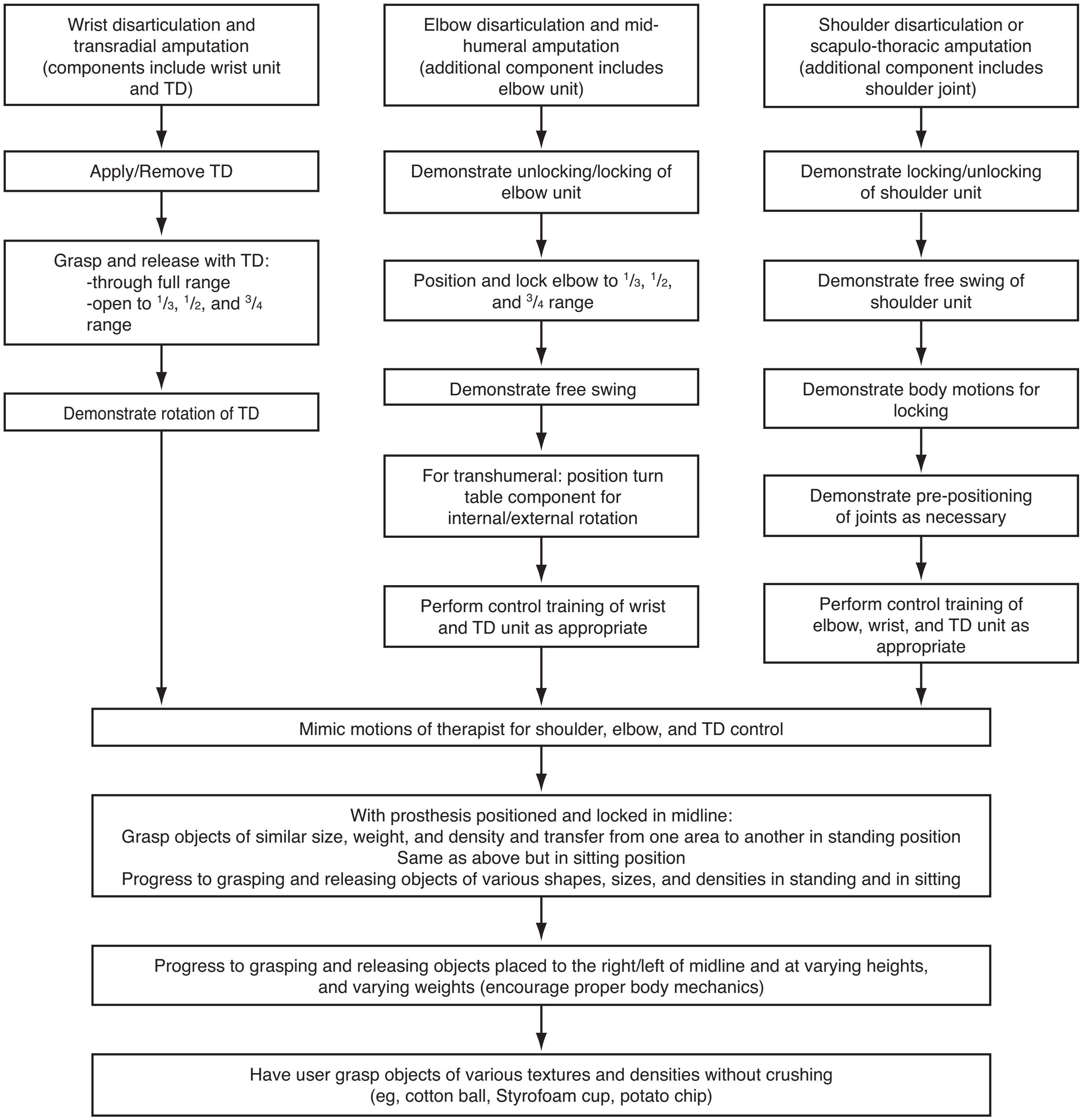

Figure 18-10. Controls training for body-powered prosthesis by level of amputation.
TD: terminal device

suredly requires the use and operation of a tool, or interaction with an object, such as a carpenter's tool, a musical instrument, a cooking utensil, or a machine. The third characteristic is that advanced training involves completing a multistepped complex task with many required bimanual movements. In the language of the occupational therapist, it could best be said that advanced prosthetic training is "occupation-based." Treatment activities in this phase are less static and generally challenge the therapist to remove the patient from the clinic setting. In this way, the advanced rehabilitation is not a series of similar, repetitive movements such as moving one object after another to the same location, as would be the case for phase three training.

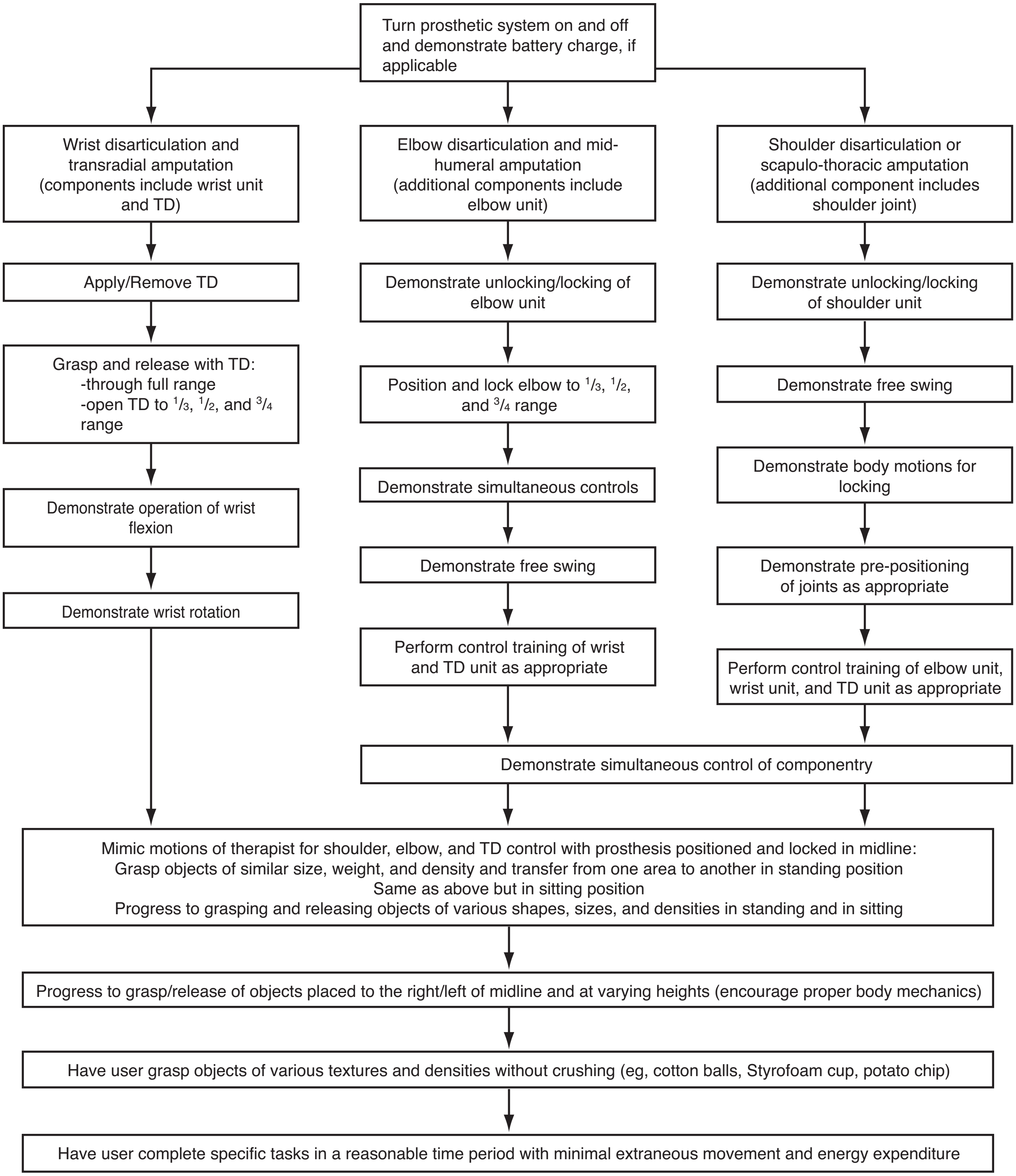

Figure 18-11. Controls training for myoelectric prosthesis by level of amputation.
TD: terminal device

The fourth characteristic is that this type of training should involve the prosthesis of choice for the patient. Users are encouraged to try different TDs during activity performance to determine which device best meets their needs. Whether the individual self-selects the myoelectric or body-powered prosthesis as his or her preferred

Name:	Age:	Occupation:	Date of Test:
Therapist:	Sex:	Type of terminal device:	

RATING GUIDE KEY:

0 Impossible	1 Accomplished with much strain, or many awkward motions	2 Somewhat labored, or few awkward motions	3 Smooth, minimal amount of delays and awkward motions

ACTIVITIES OF DAILY LIVING	**0**	**1**	**2**	**3**
PERSONAL NEEDS:				
Don/doff pull-over shirt				
Dress button-down shirt: cuffs and front				
Manage zippers and snaps				
Don/doff pants				
Don/doff belt				
Lace and tie shoes				
Don/doff pantyhose				
Tie a tie				
Don/doff bra				
Don/doff glove				
Cut and file finger nails				
Polish finger nails				
Screw/unscrew cap of toothpaste tube				
Squeeze toothpaste				
Open top of pill bottle				
Set hair				
Take bill from wallet				
Open pack of cigarettes				
Light a match				
Don/doff prosthesis				
Perform residual limb care				
EATING PROCEDURES:				
Carry a tray				
Cut meat				
Butter bread				
Open milk carton				
DESK PROCEDURES:				
Use phone and take notes				
Use pay phone				
Sharpen pencil				
Use scissors				
Use ruler				
Remove and replace ink pen cap				
Fold and seal letter				
Use paper clip				
Use stapler				
Wrap package				
Use computer: typing, access Internet				
Demonstrate handwriting				

COMMENTS:

ACTIVITIES OF DAILY LIVING	**0**	**1**	**2**	**3**
GENERAL PROCEDURES:				
Turn key in lock				
Operate door knob				
Place chain on chain lock				
Plug cord into Wan outlet				
Set time on watch				
HOUSEKEEPING PROCEDURES:				
Perform laundry				
Fold clothes				
Set up ironing board				
Iron clothes				
Hand wash dishes				
Dry dishes with a towel				
Load and unload dishwasher				
Use broom and dustpan				
Operate vacuum cleaner				
Use wet and dry mop				
Make bed				
Change garbage bag				
Open/close jar				
Open lid of can				
Cut vegetables				
Peel vegetables				
Manipulate hot pots				
Thread a needle				
Sew a button				
USE OF TOOLS:				
Saw				
Hammer				
Screw drivers				
Tape measure				
Wrenches				
Power tools: drill, sander				
Plane				
Shovel				
Rake				
Wheelbarrow				
CAR PROCEDURES:				
Open and close doors, trunk and hood				
Perform steps required to operate vehicle				

COMMENTS:

Figure 18-12 (left page). The "Unilateral Upper Extremity Amputation: Activities of Daily Living Assessment" is a rating guide that provides a comprehensive list of activities of daily living that a unilateral amputee should be able to accomplish.
Adapted with permission from Atkins DJ, Meier RH. *Comprehensive Management of the Upper-Limb Amputee*. New York, NY: Springer-Verlag; 1989.

EXHIBIT 18-4

PHASE FOUR: ADVANCED PROSTHETIC TRAINING: UNILATERAL AND BILATERAL, ALL LEVELS

Goals: 4 to 10 Weeks after Prosthetic Delivery

1. Patient will be able to perform self-selected advanced prosthetic activities with smooth movements, minimal amount of operational delays, or awkward motions and postures.
2. Patient will be able to identify community resources for prosthetic needs.
3. Patient will be able to identify resources for vocational planning.

prosthesis, the advanced training should be geared toward fine-tuning the operation and control of that prosthesis as needed to engage in the appropriate tasks at this level of rehabilitation. The fifth characteristic is that there is a meaningful product or outcome upon task completion. For example, the patient would have built the frame, weeded the garden, assembled the weapon, dug the hole, or repaired the engine. It is helpful to encourage patients to complete a "prosthesis thesis" as a capstone assignment from this phase of training. Several individuals have completed carpentry projects, leather belt or wallet projects, and complex stained glass or wood-burning crafts (Figure 18-13).

Phase four includes a variety of advanced tasks that patients perform once they demonstrate proficiency with the prosthesis in phase three. Additionally, these advanced activities are specific to the patient's interests, hobbies, family, and work goals. Patients are trained on tasks such as military warrior tasks, yard work, home repair and maintenance, shopping, meal preparation, child care, pet care, and recreational and sports activities. Tasks within these general categories challenge the individual to complete the task successfully with the prosthesis. The patient who passes the rigors of this level of training is often identified by the rehabilitation staff as "integrator" because of his or her success at integrating the prosthesis into the motor skill repertoire, thereby attaining the goal of this phase of rehabilitation. Overall, the patient's movements should be coordinated, smooth, and precise with accurate and consistent control of the operations of the prosthesis using ergonomically sound postures proximally. Patients who elect to not utilize a prosthesis should be able to perform these tasks as independently as possible or have an identified plan to complete such tasks with the assistance of others as necessary.

Military Warrior Tasks

The military warrior tasks category includes tasks specific to basic warfighter skills such as assembling and disassembling, firing, repairing, and cleaning a military service weapon; donning and doffing a gas mask; using a military radio; and assembling a rucksack with all appropriate military gear. Many SMs are interested in completing these tasks because they solidify their compromised identity. Furthermore, those who wish to remain on active duty can demonstrate that they can meet the minimum standards of required skills for military service.

Yard Work, Home Repair, and Maintenance

The responsibilities of yard work and home maintenance are complex and varied and the patient must work with a variety of tools to complete the identified task. Yard work activities are performed outside of the clinic utilizing gardening tools such as spades, shovels, hedge clippers, and wheelbarrows. These tasks require movements in many planes with various tools that require difficult postures and much upper body and trunk muscle strength. As the patient identifies his or her previous home responsibilities or predicts those of a future living environment, the therapist may set up simulated tasks in a functional apartment. The individual may perform tasks such as taking garbage out, fixing a leaky sink, replacing a light bulb, changing bed sheets, running the vacuum, unloading groceries into the pantry, and replacing the bathroom shower curtain liner. Whatever the task, the patient gains self-confidence to return to independence in a home environment through practice of "real-life" chores.

Shopping

Shopping is its own distinct category of training because of the many functional obstacles to overcome in the commercial market square. The

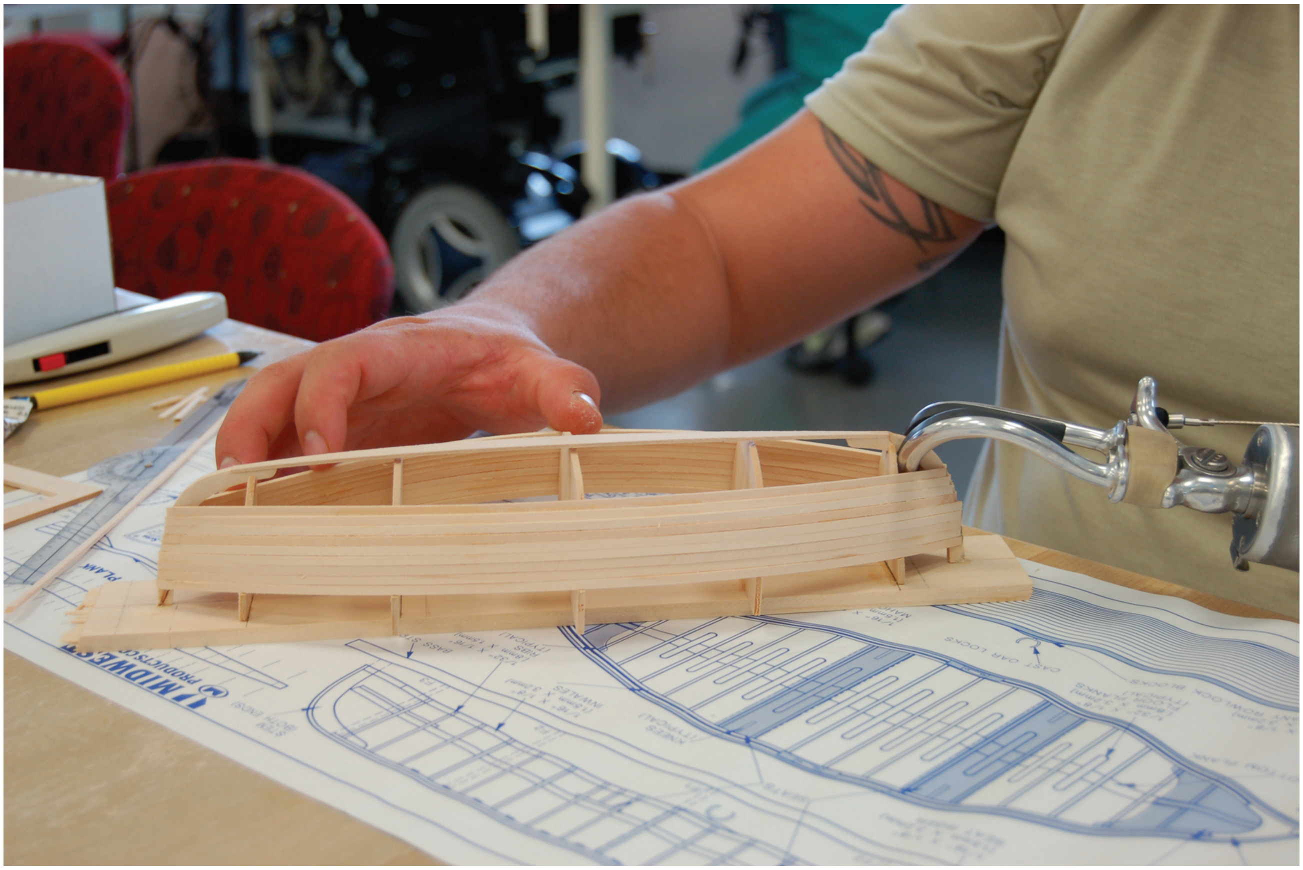

Figure 18-13. This patient is using the body-powered prosthesis to assemble a sailboat made of wood. This project requires fine-tuned prosthetic skill and control; these skills are addressed during advanced prosthetic training.

individual must shop for groceries and be able to reach many types of packages from shelves of variable heights. Now that most supermarkets have self-service check-out lanes, the patient must train to complete the entire gamut of tasks related to purchasing, scanning, bagging, and paying for groceries. The final money transaction should be practiced using the automated credit card machine and the automated cash machine.

Shopping for clothes and shoes must be addressed for the specifics inherent in such tasks. For example, upper limb amputees who choose to use elastic shoe laces must be aware of the difficulty they will have when shoe shopping. This makes the case for learning to tie one's shoes one-handed or using a prosthesis, even if the individual often relies on elastic shoe laces. For clothes shopping, it can be awkward and tiresome for an upper limb amputee to shop for shirts that accommodate the prosthesis and possible harnessing systems if a body-powered system is the individual's preferred prosthesis.

Meal Preparation

Meal preparation makes up a special category of this phase of rehabilitation. Throughout the patient's rehabilitation, he or she participates in a weekly cooking group. This group is the individual's first exposure to one-handed adaptive equipment such as one-handed cutting boards, can openers (Dycem Limited, Warwick Central Industrial Park, RI), and electric mixers. When the patient reaches this phase of training, he or she must complete the entire meal preparation process from cooking to serving to cleaning. There are many challenges and rewards in cooking. Completion of this high-level training gives the individual a sense of accomplishment and a strong sense of independence.

Child Care and Pet Care

Child care and pet care are addressed at this phase of rehabilitation. The tasks in this category are numerous, changing, and varied. The patient must identify his or her responsibilities related to child and pet care, and the therapist must perform careful task analysis to offer detailed training. The use of therapy dogs allows for training in pet care to be realistic. It is best to address child care training as it relates to the specifics of the patient's own children. Therapists have often used a doll to practice diapering, holding, bathing, swaddling, and to improve the confidence of the individual who can be apprehensive about hurting or dropping his or her own child while using the prosthesis.

Introduction to Driver's Training

It is not uncommon for an SM returning from combat to experience some amount of difficulty acclimating to driving again. Some SMs have informally reported physical incompatibilities to driving while others identify issues with hyper-vigilance that left them uncomfortable and unsure about returning to it. SMs have informally reported that the following situations made them the most nervous while driving: (*a*) potholes, (*b*) traveling under or over bridges or overpasses, (*c*) unexpected sudden flashes or sounds out of the periphery of vision, and (*d*) vehicles quickly approaching from the rear.

The rehabilitation team may use a cursory treatment as necessary to prepare the patient for driver's training utilizing driving simulators within the military training facility. The driver's training simulator provides an opportunity for cursory exploration of possible modifications to assist the SM in physically operating his or her vehicle and a method to assist in desensitizing the SM to driving again. Various scenarios are introduced in a progressive desensitization method with the goal of returning confidence and comfort with driving. Reaction time and appropriateness of the reaction can be documented and recorded allowing for subjective and objective data to determine progress. This process also is a method to demonstrate and mitigate safety concerns that the SM or treatment team may have about returning to the road.

During rehabilitation, once the SM has acclimated and is ready to progress to community driving, he or she is enrolled in driver's training evaluation at local Veterans Affairs (VA) facilities. VA-certified driver's training is a multidisciplinary program and links the patient with available VA benefits related to driving. These specialists identify appropriate vehicle modification equipment used as needed to assist the patient in performing driving tasks and provide training on this equipment. They also assist in acquiring the necessary vehicle modifications. OT in the military training facility is not responsible for performing this evaluation.

Vocational Planning and Training

The vocational training category is specific to the individual's particular occupational pursuit. Those patients who choose to remain on active duty may be faced with learning new skills to complete their current military occupational specialty (MOS), consider changing their MOS, and learning new skills. Others may choose to leave the service and pursue a new or familiar civilian occupation. This decision can be further complicated by the addition of a prosthesis(es).

The occupational therapist must help patients sort through the various tasks associated with their particular occupational pursuits or MOS demands. To facilitate this all patients should receive an initial screen to determine appropriateness for a functional capacity evaluation (FCE). This evaluation may be completed to determine an individual's ability to perform work-related activities through assessment of strength, flexibility, endurance, cardiovascular function, and maintenance of certain positions. This is an intense evaluation performed by the occupational therapist and includes, but is not limited to, assessment of the following:

- repetitive heavy lifting,
- carrying,
- pushing/pulling,
- repetitive squatting,
- stair climbing,
- ladder climbing,
- kneeling,
- bending, and
- overhead work.

Completion of an FCE may take anywhere between 3 to 5 hours over 1 to 2 days, depending on the individual and his or her specific diagnosis(es).

Flexibility of the FCE allows variation in the prosthesis utilized during testing. For example, therapists may choose to test an upper limb amputee in his or her ability to utilize both a body-powered and a myoelectric prosthesis in various functional tasks including lifting, carrying, and positional tolerance tasks. Individual prosthetic manufacturer recommendations for maximum weight guidelines should be carefully considered to ensure patient safety while performing lifting and carrying tasks.

Occupational therapists also may choose to design individualized custom FCE protocols to objectively measure a patient's ability to perform basic military warrior tasks. In addition, custom FCE protocols may be established to objectively measure a patient's ability to perform the specific tasks in his or her MOS/area of concentration (AOC). Further identification of a patient's vocational and educational interests may be necessary if an individual does not wish to or is unable to remain in the military secondary to physical and/or cognitive deficits.

Findings from FCE testing may be used to support a patient's medical evaluation board or physical evaluation board. Specifically, data obtained during the FCE testing may be used to determine an individual's fitness to return to duty. Furthermore, individualized retraining may be necessary to enable an individual to remain in his or her current MOS or AOC or preparation for transition to a new MOS or AOC.

If the SM decides to leave the military and pursue a civilian occupation, he or she is linked with a vocational rehabilitation counselor and resources through the Department of Veterans Affairs (VA). To facilitate this relationship, it is recommended that the VA vocational rehabilitation counselor be colocated with the OT service in the military training facility. Once linked to the VA vocational rehabilitation counselor, patients undergo appropriate evaluation if necessary and may see a VA occupational therapist for an FCE. Additionally, VA rehabilitation counselors provide software and training packages to all eligible beneficiaries.

Whether or not the patient decides to remain on active duty, therapists should research vocational resources and plan for future vocational pursuits with patients. For example, those who elect to pursue a welding career in their hometown may benefit from individualized research and planning with the therapist to ensure that they have a formidable plan to meet this vocational pursuit. An example is identifying a local welding union and locating what companies may have job openings.

Adaptive Equipment and Environmental Modifications

To maximize independence and function in ADLs, wounded SMs may require various adaptive equipment and environmental adaptations. Assessment is made early for adaptive equipment or environmental modification needs and continues until patients prepare for discharge and transition into their future occupational and home environment. OT serves a significant role in this assessment. While still an inpatient the therapist can assess the SM's current use of electronics and help him or her acquire the resources to begin this process. Once determination is made on needs and previous premorbid use of electronics, items may be ordered. SMs may be trained and begin using these devices to assist in return to duty or eventual discharge to the VA system.

Programs, such as the Computer/Electronic Accommodations Program (CAP) offered through Tricare, offer SMs various types of adaptive equipment to enhance independence in vocational activities. CAP equipment can be obtained to increase independence for individuals with vision loss, low vision, or are deaf or hard of hearing, and those with cognitive, communication, and dexterity disabilities, which frequently occur as a result of combat. As the patient progresses through the final phase of rehabilitation, he or she explores vocational options. If adaptive equipment facilitates independence in work-related tasks, a CAP assessment is initiated as soon as possible. Patients who elect to transition to civilian occupations should initiate a CAP assessment as early as possible in their final phase of rehabilitation to facilitate a rapid and seamless transition to the VA vocational rehabilitation counselors.

Environmental modifications necessary within the home are acquired through the VA. A therapist certified in adaptive technology from the regional VA Medical Center completes the necessary assessments of various environmental modifications needed within the home.

Exercise Prescription Considerations

For those who enjoy activities of low to moderate intensity, fishing, gardening, walking, golf, biking, and swimming are exercise options. Swimming, in particular, is ideal recreational activity secondary to its relatively low overload on skin, muscles, and joints as well as its accessibility and no requirement to use an activity-specific prosthesis. Cardiovascular demands vary because the sport can be geared to target heart ranges as low as 50% of maximum heart rate. Intensity begins with 5- to 15-minute exercise sessions that follow established target heart ranges for the individual. Progression to a continuous exercise session lasting 30 to 40 minutes will guarantee sport-specific aerobic conditioning while in the water.

The amputee seeking moderate to high activity levels of exercise has even greater recreation choices including sports such as running, aerobic dance, weight lifting, and skiing as well as racquet and team sports to address these needs. Those who choose to exercise with their prosthesis must have a proper fit because of the significant shear forces experienced during these activities. A prosthetist may be consulted regarding sport-specific prosthetic options and special prosthetic modifications before engaging in a sport.

Recreational and Sports Activities

Recreational and sports activities during this phase of training are appealing to young active SMs. Various recreational choices exist for low to moderate and moderate to high levels of exercise intensity. Many customized prostheses and TDs are available on the commercial market to facilitate the return to previously enjoyable activities.

The roles of the amputee clinical team are interdependent when attempting to train the patient for recreational and sport activities. The occupational and/or recreational therapist interviews the patient to determine his or her leisure history or recreational interests and conveys this information to the rehabilitation team to ensure future treatment is targeted at achieving the physical demands of the chosen activity within a timely manner. The physical and occupational therapists should train the patient in the prerequisite conditioning components of the sport. In addition, the team prosthetist is consulted to determine appropriate prosthetic adaptations necessary for proficiency in the identified task. These devices are purchased and/or modifications are completed and the occupational therapist trains the amputee accordingly with the new equipment. Once all minimal physical and adaptive needs are met, the recreational therapist begins the sport- or activity-specific training with other clinicians acting as consultants. Often a patient's love of and desire to resume a certain leisure interest or sport serves as a reward for participation during previous phases of the protocol to advance to this category of training.

COMMUNITY REENTRY AND REINTEGRATION

The community reentry and reintegration processes are a significant component of life that any individual recovering from trauma must face. No matter how well an individual is prepared for interactions in the community, the demands of the community cannot be re-created within the confines of the clinic. Furthermore, a challenging first experience without support can result in a major setback for the patient, whereas a positive and supportive first experience typically leads to more. Although these experiences may be overwhelming and frightening for the patient, they are invaluable in recovery.

Occupational and physical therapists coordinate programs for injured SMs with input from all interdisciplinary team members. The program, which is an important part of recovery, is an early reminder of the crux of the entire program—to return the patient to the highest attainable level of participation in life. The goal is to get the patient back into the community—at some level—very early in recovery. This alleviates the fear and stress of reentry that is common following a devastating and physically altering injury such as limb loss.

To participate in the therapeutic outing the patient must be medically cleared. He or she must be off contact precautions, be able to tolerate sitting in a wheelchair for at least 2 hours, and be allowed to stop intravenous medications for 2 hours. The patient may still require wound vacuums, but they are portable. The patient does not have to be able to complete transfers independently because therapists and nurses can assist with them. Wheelchair accessible transportation is utilized for the therapeutic outings. The patient also must be psychologically ready to encounter the world outside the hospital and be willing to participate in the therapeutic outing. The entire team believes that the sooner the patient overcomes the fear of reentry into the community, the easier each subsequent trip becomes.

Early in their rehabilitation patients tend to manage better on a small trip, such as to a local shopping mall or restaurant. These are often the most meaningful trips for the therapists because they accompany the patient across a new threshold toward independence outside of the hospital.

For most patients, it has been some time since they have been back in the United States, so the readjustment to life outside the combat zone must be addressed. Patients often comment that they are "lost without their weapon" and feel unsafe without having the protection of "being armed." As discussed previously in the "Introduction to Driver's Training" section, patients become frightened or anxious on bridges or underpasses while traveling on the busy highways in a bus or van. Patients also may feel a sense of powerlessness and panic in crowded places, such as restaurants and malls. The hyper-vigilance while riding in a vehicle and the lack of tolerance for public places are often other sources of anxiety because patients did not expect to feel this way once they returned home. Patients need to be reassured by accompanying staff that this is a normal part of community reentry and their feelings and concerns should be openly discussed and addressed. The therapist discourages the patient from isolation, avoidance of public places, and traveling while reassuring the patient that his or her emotions and reactions will get easier with each subsequent outing.

The community reentry and reintegration program has gained much support from outside not-for-profit organizations. These organizations have made phenomenal opportunities available to patients allowing them to engage in all types of sports such as golfing, fishing, bowling, wheelchair basketball, snow and water skiing, canoeing, and horseback riding. Also, a program created through the American Red Cross in the national capitol region establishes tours around such sites as the White House, FBI building, US Treasury Department, US Capital building, Pentagon, and the Spy Museum. The therapist is encouraged to seek out local community opportunities for participation.

Therapists plan and coordinate the outings well in advance. Due to patient volume and patients' individual needs and demands when participating coupled with the community reentry program's growth, there are often two or more trips each week. This demands astute attention by team members that care for these patients and therefore community reintegration is a topic at the weekly team meetings. The interdisciplinary team is interested in knowing how the patient tolerates the community outing because this provides valuable information about the psychosocial status of the recovering patient.

The Adaptive Sports Program: An Extension of Community Reentry

Occupational therapists understand disability and have the skill set to address all areas of performance with special consideration to the patient factors and context of sport. The use of therapeutic sports as part of community reentry addresses all patient factors including (*a*) sensory, (*b*) neuromuscular skeletal, (*c*) cardiovascular, and (*d*) mental. Sports can generally be adapted to meet the patients where they are along a continuum of skill level.[22] The physical task demands of balance, strength, dexterity, and endurance inherent in sports continually prove challenging to the military patient population. Therapists understand that satisfaction in life is directly related to one's ability to participate fully in life, with as few restrictions as possible. In this way, therapists use sports to place the spotlight on the ability while de-emphasizing the disability.[22]

Therapeutic recreation has long been used to promote the achievement of optimal health through sports and leisure.[23] Adaptive sports consist of any sporting activity that has been modified to enable participation by someone with a disability. The Adaptive Sports Program (ASP) raises the performance bar from basic ADLs to extreme sports of all kinds. The engagement in sports as a therapeutic medium increases motivation, eases feelings of idleness, and alleviates loneliness and depression.[23] Sports naturally promote high-level skills, so occupational and physical therapy staff work in tandem to prepare patients for participation in sports.

Occupational and physical therapists utilize government and private organizations that offer adaptive sports opportunities. The Disabled American Veterans (Cold Spring, Ky) and Paralyzed Veterans of America (Washington, DC) offer opportunities to the military patients. The National Veterans Wheelchair Games are one of many sporting opportunities sponsored by the Paralyzed Veterans of America. Private nonprofit organizations such as the Disabled Sports USA (Rockville, Md) and Project Healing Waters (Washington, DC) are two of many organizations that also contribute to the mission of integrating sports into the recovery plan of the war-wounded SMs. Many of these organizations were established by veterans of prior and current conflicts to aid in the recovery of injured SMs returning from Operation Enduring Freedom/Operation Iraqi Freedom.

Overall, participation in the ASP facilitates the intrinsic motivation of the competitive and athletic military patient population. Patients learn adaptive skiing and snowmobiling in various Colorado cities; they learn adaptive kayaking in Maryland and Virginia; and they learn adaptive fly fishing in Montana. Some take on more physical challenges through participation in the Baton Death March, the Army Ten Miler, or National Veterans Wheelchair Games where they compete for medals in wheelchair sports such as quad rugby, basketball, skeet shooting, and softball.[24]

Through the ASP, the energy of the military culture physical competition and camaraderie is harnessed. The ASP simulates a familiar culture of competitiveness, in which the young, active, and adrenaline-seeking military patients thrive. The built-in activity demands of sports allow therapists to transcend the traditional activities of cones, blocks, and pegs that are familiar and necessary to most OT clinics. Moreover, the ASP represents "the doing" that defines so much of the therapeutic process innate to OT resulting in an evolution of recovery of function that can lead the SM to an active lifestyle following a disabling injury. This active lifestyle might likely include an adapted sporting activity.

DISCHARGE PLANNING

Before the global war on terror, the options for SMs with limb loss were more limited. Now SMs can requalify for active duty or pursue civilian careers. Whether or not the SM has the desire or the ability to return to active duty, the goal of the rehabilitation team is to help each patient achieve maximal function and the highest quality of life possible.

The discharge plan begins on the day the rehabilitation team is introduced to the injured patient. As is true with civilian patients undergoing rehabilitation, the information gathered during the initial evaluation serves as the foundation for discharge planning. The intent of a discharge plan is to provide a smooth transition from one level of care to another.

Discharge planning is best performed by a multidisciplinary team, along with the patient and the family. The medical members of this team may consist of a physiatrist who acts as coordinator for medical and surgical subspecialists, nurses, occupational and physical therapists, prosthetists, social workers, psychologists, dieticians, pharmacists, and psychiatrists. This group may also include a physical evaluation board liaison officer and a VA counselor to assist with the military medical disability system. It is suggested that this team meet weekly through team conferences and outpatient amputee clinics to ensure communication for quality and efficient care of every patient.

Many injured SMs have severe concomitant injuries in addition to an upper limb amputation that affect the choices that they must make about the lifestyle they will strive to live. Understanding the individual's lifestyle before admission will give insight into possible future goals. Knowledge about the patient's preexisting family/support system, physical condition, emotional/cognitive status, educational level, vocation, and avocations cannot be understated. The patient's culture and primary language—if other than English—also will impact discharge planning.

Follow-up Care

Many combat-injured military personnel will need provision for ongoing medical care that includes—at minimum—regular follow-ups with a physiatrist who will act as a coordinator for any specialty care required. Ongoing medical care includes regular follow-up visits with a prosthetist, psychologist, and/or psychiatrist, and intervention as needed with occupational and physical therapy, vocational rehabilitation, social work, and subspecialty medicine.

Resources

Providing the patient with resources to support ongoing rehabilitation is critical. For persons who have undergone rehabilitation in a protected hospital environment with significant support systems in place, transitioning to care outside the hospital is a very turbulent time. Transitions to different levels of care outside of this support system bring new stresses that frequently go understated in discharge planning. The individual does not often recognize these stresses until after the transition has occurred. To reduce the occurrence of feelings of isolation, the rehabilitation team introduces patients to numerous resources in preparation for discharge including the (*a*) Amputee Coalition of America (Knoxville, Tenn), (*b*) peer support, (*c*) local support groups, and (*d*) specialty interest groups for amputees. A number of nonprofit organizations for disabled veterans as well as for civilians with a disability provide recreational opportunities and other types of support. Paralyzed Veterans of America and Disabled American Veterans are two groups that support wounded veterans. Publications such as *InMotion* magazine (Amputee Coalition of America, Knoxville, Tenn) and *Challenge* magazine (Disabled Sports USA, Rockville, Md) can be great resources for both military and nonmilitary persons.

REHABILITATION FACTORS

Concomitant Injuries

As stated throughout this text, individuals who have sustained combat injuries frequently have concomitant injuries that must be considered when planning the rehabilitation process. Such injuries may influence available treatment options, treatment progress, and progression through rehabilitation phases. It is critical that the team communicate at least weekly on patient progress to ensure that all care the patient receives meets his or her needs. Additionally, communication among facilities actively engaged in the provision of treatment to those individuals who require highly specialized treatment in conditions, such as TBI, visual loss, or burns, is critical. Highly specialized centers may be located throughout the United States and communication may be facilitated through video teleconferencing or telephone conferences.

Once medically stable, those individuals with TBI are rehabilitated through one of five VA hospitals across the United States. Coordination of care is through the accepting physician and team and also through visual and administrative patient handoff between the gaining and losing facilities. The same process is repeated once the patient completes his or her TBI rehabilitation and returns to the gaining amputee center of excellence. The patient initiates the phase of amputee rehabilitation as appropriate. Depending on the severity of his or her TBI, rehabilitation must be adjusted according to the patient's needs.

Other factors that must be addressed or considered throughout rehabilitation include burns or skin grafts, infections, multiple organ injuries or failures, visual deficits, hearing and/or vestibular deficits, multiple extremity amputations, fractures, shrapnel injuries, peripheral nerve injuries, neuroma(s) development, heterotropic ossification, and risk of joint contracture. Psychosocial injuries and posttraumatic stress disorder also play a factor in rehabilitation. The impact of comorbid injuries sustained in combat adds to the complexity and intensity of rehabilitation but must be addressed appropriately to achieve a successful patient outcome.

Bilateral Upper Limb Amputee Training Considerations

Although any upper limb amputation challenges a person's physical and emotional self, a patient who loses both upper limbs will require more inner strength, patience, and willingness to persevere. A solid support system will augment the inner strength required during some of the challenges of rehabilitation. Additionally, the needs of a patient with bilateral upper limb loss requires an experienced team that can blend all of the current technology and creativity required to maximize the patient's independence and performance in his or her desired occupational performance areas. As soon as the team deems appropriate, a visit from a trained, matched peer visitor can be crucial to enhancing the patient's hope and vision for his or her future.

All areas of care previously described in this chapter apply to the bilateral limb loss amputee. However, some applications are unique to the bilateral limb loss amputee that would not be used by the unilateral limb loss amputee. In general, the traumatic bilateral upper limb loss amputee will usually choose to use at least one prosthesis to gain independence in ADLs. Also, he or she will require more adaptive equipment and environmental modification, and will have a stronger tendency to use the environment to achieve the most efficient task performance possible.

Another significant factor that influences a bilateral upper limb amputee's decision to use a prosthesis is the length of the residual limbs. Length significantly impacts a patient's ability to function independently and influences his or her choice of prostheses and adaptive devices. A patient with longer residual limbs can utilize the available sensory feedback area on the residual limb to oppose each limb during functional grasping. Length is also a critical factor in determining limb dominance. Typically the longer residual limb will become the chosen dominant side because of the increased functionality of either the prosthesis or the increased sensory area and sound joints available to engage in activities. Therefore, in general, the longer the length of the residual limb(s), the more independent the person will be and fewer environmental modifications will be necessary. Patients with congenital bilateral limb loss develop unique motor patterns at a young age, such as the use of foot skills. Therefore, prosthetic use varies more as compared to those with traumatic limb loss.

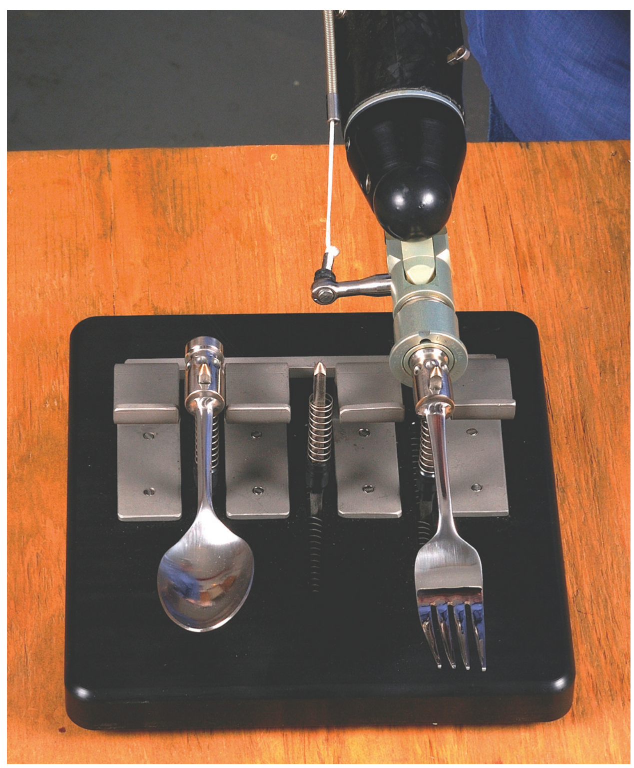

Figure 18-14. This is an example of a hands-free tool changing station.
Photograph courtesy of Texas Assistive Devices.

Of note regarding specific types of prosthetic componentry, for the bilateral upper limb prosthetic user wrist flexion is a benefit that allows the user to gain closer access to midline and to the facial area. This is critical for ADLs in which patients will use their prostheses. Certain prosthetic componentry and modified TD attachments can assist in providing increased degrees of freedom or task-specific function. Manufacturers have begun to fabricate componentry including the Five Function Wrist unit from Texas Assistive Devices (www.n-abler.org) that increases the patient's options for wrist positioning. Texas Assistive Devices (Brazoria, Tex) and TRS Inc (TRS Inc, Boulder, Colo) manufacture TD attachments that are task or activity specific, such as wrench sets, knives, hygiene items, and sports equipment. Texas Assistive Devices manufactures a hands-free tool changing station that allows a bilateral upper limb amputee to independently change the TD tool (Figure 18-14).

Many household items designed to address weakened grasp or pinch for the general population are useful to a bilateral upper limb loss amputee. A few examples include lever door handles, number pad key locks, motion sensor lighting, touch pad light switches, particular drawer pulls and handles, liquid bottle dispensers, refrigerators with in-door water dispensers, robotic vacuum cleaners, and computer controlled environments. Thanks to the evolution of computers and computer search engines, many options for bilateral limb loss amputees can be found through the Internet. As patients develop the ability to problem solve tasks that are specifically related to their needs, they begin to formulate their own solutions or ideas for problematic or difficult tasks.

RECENT ADVANCEMENTS IN PROSTHETIC DEVELOPMENT: IMPACT ON TREATMENT

In the 1980s Malone et al demonstrated that upper limb amputees fit with a prosthesis within 30 days had higher rehabilitation success.[25] This was supported by Fletchall's work evaluating "the value of specialized rehabilitation of trauma and amputation" in 2005.[26] Research and development in prosthetics are rapidly evolving, providing more prosthetic options with improved functional abilities for upper limb loss amputees.

Advances in prosthetic technology for partial hand and finger amputation levels, which have moved beyond traditional cosmetic and passive prosthesis, provide more functional joint components and incorporate remaining functionality of the residual hand and/or finger. Access to various finger prosthetic devices requires greater lead time than most other prostheses. Prosthetic options range from devices that are connected to a wrist-hand orthosis, utilization of the X-finger (Didrick Medical Inc, Naples, Fla), customized orthosis, and cosmesis that take advantage of residual active digit motion for increased function. Furthermore, future developments are underway as a result of research funded through the global war on terror to allow greater prosthetic fine motor control. These advances and others will influence future rehabilitation approaches and possibly a new rehabilitation standard of care will evolve.

Targeted reinnervation is a surgical option to provide an increased number of myosites by utilizing remaining distal peripheral nerves that are surgically placed over motor end points on healthy proximal denervated musculature of the residual limb. Ultimately, this procedure provides additional available muscle sites to control componentry necessary for prosthetic control for a high-level amputee. Another benefit of this procedure is the potential of sensory feedback from the skin over the reinnervated areas. SMs interested in this procedure are considered for eligibility once they have demonstrated proficiency with both a body-powered and a myoelectric prosthesis and have intact cognitive abilities to properly control and operate the prosthesis. It takes a minimum of 6 months to recover. During this time the SM is educated in scar management and followed as needed by OT. After recovery, the residual limb is evaluated to determine reinnervation of the newly created myosites. It is expected that by month six, reinnervation is complete and the SM should be able to be refit with the prosthesis and begin training with the new myosites and prosthesis. Once reinnervation occurs, prosthetic retraining is initiated in the same manner as described in this protocol but faster as the patient tolerates (see chapter 27, Future of Artificial Limbs, for more details).

Although engineering and electronic developments for the mass market continue to influence prosthetic technology development, federal and military sources have significantly increased their support for development of upper limb prosthetic technology. The Defense Advanced Research Projects Agency (Arlington, Va) Revolutionizing Prosthetics initiative is an example of this type of support. There are two programs under this initiative: (1) Revolutionizing Prosthetics 2007 and (2) Revolutionizing Prosthetics 2009. The intent of Revolutionizing Prosthetics 2007 is to develop a robotic prosthesis that looks and performs like a human arm. The prosthesis will perform functional range of motion at the shoulder, elbow, wrist, and digits; have a cosmetic cover that is durable and appears like skin; and weigh less than 8 pounds, the weight of the human arm.[27] Revolutionizing Prosthetics 2009 program will provide the upper limb prosthetic user with proprioceptive, sensory, temperature, and vibratory sensations.[28] Furthermore, the prosthetics that result from both Defense Advanced Research Projects Agency programs will be controlled through a neural interface, meaning they will be controlled through the user's brain as opposed to myosites.[27]

Research Updates

At the established centers of excellence across the country, the recent influx of polytrauma patients managed and treated has provided research opportunities that will result in the advancement of medical care and rehabilitation of these patients. Multiple studies have been proposed and are in various stages of research. A review of completed and current studies as well as discussion for future research will be presented in the following paragraphs.

Firearm Training Simulator

In 2004 the Telemedicine and Advanced Technology Research Center funded a study to assess the use of a virtual reality training simulator called the Firearm Training System (FATS). FATS is a projection-based type of virtual reality (VR) that uses a computer-generated image that creates a virtual environment to allow the patient to be part of a scenario in three dimensions, a virtual world. FATS has distinct weapons that look and feel authentic to SMs; however, instead of live ammunition, carbon dioxide discharges from the muzzle, which mimics the recoil of an actual weapon. Through FATS, patients work on weapons marksmanship. In the scenarios generated through FATS VR, patients complete training to replicate a live-firing range or select participation in a situation that places them in the middle of a simulated battle. The use of VR in physical rehabilitation can bring the complexity of the real world to rehabilitation while eliminating the associated risks.[29] The funded study enrolled 35 patients, two female and 33 male, with upper limb amputation or severe peripheral nerve, bone, or soft tissue injury.[30] The purpose of the study was to assess the number of patients that—with guided training—would achieve a basic proficiency status of "qualified" to fire a military service weapon. The patients had a choice of weapon selection. Six patients shot the M-9, 20 patients shot the M-4, and nine patients shot the M-16.

Eighteen failed to qualify with their chosen weapon on the initial marksmanship test; and in surprising contrast, 17 did qualify on the initial weapons fire.[30] By the conclusion of the study, all but one qualified with a military service weapon, yielding an overwhelmingly successful outcome of the FATS study. The patients were able to remaster a basic military skill that would not have been possible to train for safety reasons using real weapons at a live-fire range. The average time spent training was 9 hours; 23 SMs completed the recommended 10 hours of training.[30] Seventeen of the study participants were upper limb orthopaedic patients. They averaged 69% of targets hit on their initial marksmanship score and 88% of targets hit on their exit score, an average increase of 19%.[30] Eighteen participants were upper limb amputees. Eight of the study participants were transradial amputees, three of whom lost their dominant hand and therefore learned to shoot cross-dominance. The transradial amputees averaged 71% of targets hit on their initial marksmanship score and 84% of targets hit on their exit score, an average increase of 13%.[30]

Ten of the study participants were classified as transhumeral amputees and two were shoulder disarticulation amputees. Six of the participants lost their dominant arm. They averaged 68% of targets hit on their initial marksmanship score and 82% of targets on their exit score, an average increase of 14% (Table 18-3). Therapists believed that the patient's premorbid skill and training level, strong intrinsic motivation to return to soldier skills, and keen interest in VR aided in the pilot study's success. Many reported that the skills learned through FATS training were beneficial to their overall rehabilitation. Based on feedback from therapists and patients who were involved in the pilot study, the use of VR for weapons training offered identity-restoring therapeutic benefits, as well as the inherent task demands of eye-hand coordination and motor control. FATS is a standard treatment in OT for combat-wounded veterans.

Voice Recognition Software

Assistive technology offers a modern day portal to independence for people with disabilities.[31] Voice recognition technology is a type of assistive technology that allows a patient with compromised use of one or both upper limbs the opportunity to control voice-sensitive electronic devices that respond to human speech. Computer assistive technology systems called environmental control units enable the patient to control such items as lights, doors, and home appliances. Some less complicated systems based on computer software allow human speech to operate a personal computer. The technology of voice recognition software offers a viable alternative

TABLE 18-3

FIREARMS TRAINING SIMULATOR DATA: PERCENTAGE CHANGE FROM INITIAL TO FINAL WEAPONS TESTING BASED ON TYPE OF INJURY SUSTAINED BY PARTICIPATING SERVICE MEMBER

Injury Type	Average Targets Hit on Initial Test	Average Targets Hit on Final Test	Percentage Change
Upper extremity orthopaedic	69%	88%	19%
Transradial amputation	71%	84%	13%
Transhumeral amputation	68%	82%	14%

Source: Yancosek K, Daugherty SE, Cancio L. Treatment for the service member: a description of innovative interventions. *J Hand Ther.* 2008;21:189–195.

for standard computer keyboard operation that may be disrupted by the loss of function with one or both hands. In 1990 Lazzaro suggested that technology may serve as an electronic bill of rights to the physically challenged.[31]

The Telemedicine and Advanced Technology Research Center funded a qualitative pilot study that evaluated the functional outcome of training patients on voice recognition software for basic computer operation. The objective of this study was to determine the usefulness of integrating voice recognition software training into a comprehensive rehabilitation program for individuals with upper limb amputation(s) or orthopaedic injuries impairing upper limb function. Patients referred for OT services meeting inclusion criteria were considered for the study.[30] Fifteen patients, 13 male and 2 female, participated in this study. The software utilized was Dragon Naturally Speaking (DNS) version 7.0. Resources for assistive technology were provided through CAP.[32] Training occurred in three phases and included (1) instruction on software use, (2) command memorization, and (3) the opportunity to take a laptop out of the clinic for personal use and practice time.[30] Software training was conducted by a certified software instructor over the course of five class rotations with four separate class dates composed of 2 hours of training per class.[30] Participants in each of the five class rotations received a minimum of 8 hours of instruction. Investigators tracked the number of hours each person spent training on the software. This intervention was provided in addition to the standard rehabilitation care plan, and the patient consented to the time commitment inherent in study participation. All of the subjects included participated throughout the study.[30]

A post-training survey was mailed to participants after completion of their individual Medical Evaluation Board. The survey obtained qualitative data related to the ultimate usefulness of the software and the training. Questions sought to determine the subject's final occupational outcome (ie, did he or she remain in the military, enroll in a college, or obtain employment) and whether he or she utilized the DNS software. Of the 15 follow-up surveys sent to participants, 9 were completed and returned. The six participants that did not reply were unable to be contacted by telephone or e-mail. The average training time of the nine participants who returned the survey was 7.25 hours. Of the nine surveys returned, six of the study participants had enrolled in college and four stated they used DNS version 7.0 to write all of their papers and long e-mails and to surf the Internet. The two remaining participants went to college but did not use DNS. One explained that despite having been trained on the software it was easier to "hunt-and-peck" and the other "nonuser" stated the orthopaedic condition that had rendered him unable to type during rehabilitation had resolved. Therefore, he was able to type. Three participants who completed the follow-up surveys did not go to college and all reported continued use of DNS for e-mails and word processing for employment and personal tasks. A quote from a survey by one of these three participants reads, "Voice makes it easier to navigate my PC and also increases my speed with writing letters and e-mail." Another participant commented, "Dragon was outstanding for me. It enabled me to continue to enjoy the computer. I don't feel like it's a challenge anymore." Another participant wrote, "Voice, on a daily basis, makes tasks that used to be difficult seem easy. It helped make things with PCs easier, faster, and less complicated once I became familiar with the software."[30]

The resounding positive comments of the participants and training results indicated that this training was effective. For patients with permanent disability to one or both upper limbs, the learning investment of training and utilizing voice recognition software is worth the benefit of being able to replace typing with voice activation text entry.[33] Additionally, the ability to interact with a computer is important to younger persons because they regularly engage in interactive communication to connect with others through the Internet or e-mail. These reasons provide credence to using voice recognition software in the standard rehabilitation care plan.[33]

Targeted Muscle Reinnervation

In collaboration with Brooke Army Medical Center and Walter Reed Army Medical Center, the Rehabilitation Institute of Chicago conducted a study titled "Targeted Reinnervation in Upper Limb Amputees to Improve Myoelectric Prosthesis Function." The goal of the study was to improve myoelectric prosthetic control for high-level upper limb amputees through targeted reinnervation surgery. A successful surgery may result in the availability of additional myoelectric control sites in the residual limb, the ability to control motion at multiple joints simultaneously creating a more natural motor pattern with prosthetic use, and a sensory feedback mechanism.

Recruited subjects who met inclusion and exclusion criteria were tested before the surgery with their current prosthesis. Both objective and subjective evaluations were performed on the subjects. The objective tests completed consisted of a modified version of the Box and Blocks Test, Clothes Pin Relocation Test, and Cubicle Reach Test. Subjective evaluations included a series of timed commonly performed ADL tasks that were designed to incorporate multiple joint movements of the upper limb in both standing and seated positions. Subjects underwent surgical intervention targeted at reinnervation of residual limb musculature using nerves remaining in the upper extremity. This technique is called targeted reinnervation.

Following surgery, patients were given approximately 5 to 8 months to heal before fitting of the dedicated targeted reinnervation prosthesis. The socket was modified to accommodate any changes that may have occurred in the residual limb shape and to incorporate additional myosites as a result of the targeted reinnervation surgery. Once the subject healed and fitting was completed the patient re-engaged in prosthetic training with OT to further enhance control of the myoelectric prosthesis with the additional myosites. Upon completion of prosthetic training and the patient's demonstration of adequate prosthetic control, the aforementioned tests were repeated. Follow-up evaluation was completed at 4 months and 8 months to measure and compare performance with the surgically created myosites.

The Type of Prosthesis and Its Effect on Functional Activities

The overall success of prosthetic users is still a highly debated issue. What makes a user prefer a body-powered over a myoelectric over no prosthesis use? This question remains unanswered. To provide further insight, a research project is underway to examine differing functional capabilities with a body-powered versus a myoelectric device. The purpose of the current study titled "The Effect of Upper Limb Prostheses Type on Functional Activity" is to determine the effectiveness of upper limb body-powered prostheses versus myoelectric prostheses when performing functional activities to more accurately assess an SM's potential to return to his or her MOS or AOC. The goal is to provide prosthetic engineers and therapists with pertinent data regarding the effectiveness of body-powered and myoelectric prostheses currently being provided to Operation Enduring Freedom/Operation Iraqi Freedom SMs. This study will promote a better understanding of body mechanics and pre-positioning techniques used by SMs when performing MOS/AOC relevant tasks while wearing an upper limb prosthesis.

Military upper limb amputation rehabilitation programs will benefit from the results of this study because SMs and therapists will be better prepared to select prostheses that best support SMs in their return to a specific MOS. Also, prosthetists will gain insight regarding prosthetic mechanical failures. This knowledge will aid in the development of prostheses that are effective and reliable in a field environment, allowing SMs to meet the physical demands of their MOS/AOC.

Community Reintegration Survey

Community reintegration is a critical component in rehabilitation. These activities provide motivation while simultaneously providing an opportunity to challenge and integrate the SM into everyday life, sports, and the workplace. To address difficulty in defining the parameters of community reintegration and measuring its success for a patient, a survey tool is being developed. It will aid in goal setting and prioritizing events/activities in which the SM may select to participate. Survey questions will address physical abilities and psychosocial status, both of which are important.

Multiple Exposure/Progressive Desensitization

Many SMs returning from combat have combat stress reaction and posttraumatic stress that influence rehabilitation. Graded treatment approaches have been developed and implemented to address the influence of these disorders on return to certain activities. The use of virtual simulators during firearms training and driver's training simulators provides excellent media to grade shooting and driving, respectively. SMs are provided the opportunity to gradually reacclimate and desensitize themselves from the associated trauma while engaging in these activities. It has been the rehabilitation team experience that SMs participating in these forms of therapy have improved their confidence. The FATS study has presented a solid basis for virtual simulators to help with reintegrating weaponry skills for patients with a prosthesis. However, future research to determine whether the virtual simulators make a difference in the SM's ability to recover and reintegrate into the military or at a minimum cope better with his or her future environment is warranted.

SUMMARY

Providing an environment to attempt previous activities or new challenges can lead to some of the most rewarding experiences. A wide variety of activities can be made available to support SMs before discharge from the hospital. Members of the armed forces are young, athletic, and competitive, so harnessing this desire has been incredibly successful. Some popular programs are snow skiing, water skiing, rafting and kayaking, hunting and shooting, and rock climbing. Providing resources and contacts to enable the patient to pursue or continue new activities in his or her home community can be a critical component to full reintegration.

Life is forever changing and challenging. Providing dynamic, supportive, and skilled upper limb loss rehabilitation through a comprehensive approach beginning with the medical model and progressing to an occupation-based model in a controlled living environment provides the amputee with a solid foundation. Ultimately, the upper limb amputee rehabilitation efforts are designed to provide patients with fundamental upper limb prosthetic skills to live balanced and productive lives both in and out of the military system.

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