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# Treating Individuals with Limb Loss and Limb Reduction

# Introduction

There are a range of unique considerations that come along with limb loss and each of these stands to impact the occupational therapy plan of care. In cases of acquired limb loss, individuals may experience both physical and psychosocial concerns that impact their occupational performance and ability to engage in therapy. However, individuals with congenital limb loss may also struggle with psychological adjustment when it comes to self-esteem and connecting with others. For this reason, OTs must be informed about both types of limb loss in order to effectively address all client factors that need rehabilitation or habilitation. Occupational therapy for individuals with limb loss may cover interventions from functional mobility and prosthetic training to coping skills and adapted leisure. A comprehensive plan of care that takes complications and comorbidities into account is the best way for occupational therapists to help patients within this population.



# Section 1: Variations and Risk Factors Related to Limb Loss

**References:** 1, 2, 3, 4, 5, 6, 7

Basic terminology and definitions related to limb loss are an important starting point for occupational therapists and anyone else involved in treating this population. Such information firstly allows therapists to communicate effectively about limb loss, which is essential for the sake of documentation. A breakdown of these terms also gives the therapist insight into risk factors that may be associated with certain types of limb loss.

## Congenital Limb Loss

For starters, individuals with limb loss are divided into two categories based on how they were first impacted by this health condition. One group is congenital limb loss and the other is acquired limb loss. Congenital limb loss occurs when a child is born with part or all of a limb missing. Congenital limb loss is also referred to as limb reduction, congenital amputation, and limb deficiency. In the United States, the prevalence of congenital limb loss is 7.9 in every 10,000 live births. The Centers for Disease Control and Prevention estimate that 1 in every 1,900 babies born each year have some form of limb loss. Limb reduction more often impacts the upper extremity than it does the lower body. Risk factors for congenital limb loss include pregestational diabetes, young maternal age, and male fetuses.

There are still a lot of unknowns regarding the causes of congenital limb loss. Most cases result when a fetus is exposed to certain medications, chemicals, and viruses in utero. Specifically, studies have identified concerns regarding anti-epileptic drugs for seizures and thalidomide, which is an ingredient in some medications that treat skin conditions. Some research also suggests tobacco smoke may be a possible toxin that can lead to limb reduction. In addition, mechanical forces, growth restrictions, and genetic conditions can cause a child to be born with limb reduction. The most common etiology of congenital limb loss is due to amniotic band syndrome. This condition occurs when bands within the amniotic sac wrap around part of a developing fetus. This may happen around the torso and head in rare cases, but amniotic band syndrome typically impacts the limbs. Most cases of congenital limb loss are not genetic. For this reason, mothers can take prenatal vitamins to prevent congenital limb loss and similar birth defects.

### *Terminology Specific to Limb Reduction*

When babies are born with limb reduction or limb deficiencies, there are various terms used depending on the type of limb or part of limb that is missing or impaired:

- **Alexia:** Complete absence of all segments that make up a limb
- **Intercalary defect:** Part of a limb is either absent or severely underdeveloped, but the terminal segments are normal or near normal
- **Terminal transverse:** The terminal segment of a limb is absent or severely underdeveloped
- **Longitudinal defect:** The absence or severe underdevelopment of a bone that runs parallel to the vertical axis of a limb
    - **Preaxial:** If the upper limb is affected, the child will not have the radius, thumb, or the first finger. In some cases, a child with a preaxial longitudinal deficit will also not have their second finger. If the lower limb is affected, the child will be born without the tibia and the first two toes. As with the upper limb, some children with this deficit will also not have their second toe.
    - **Central:** If the upper limb is affected, the child will be missing all fingers and half of the palmar surface. If the lower limb is affected, the child will be without two middle toes.
    - **Postaxial:** If the upper limb is affected, the child will be missing the ulna and the last finger. If the lower limb is affected, the child will be born without the fibula and the last toe. At times, children with a postaxial longitudinal deficit will also be missing the fourth finger or the fourth toe.

- **Mixed:** If the upper limb is affected, the child may lack any combination of the radius, ulna, thumb, or fingers. If the lower limb is affected, the child may lack any combination of the tibia, fibula, or toes.

## Acquired Limb Loss

Acquired limb loss is characterized by the need for a surgical amputation to remove some or all of a limb. Major trauma - such as a car accident or a crush injury - is one of several leading causes of acquired limb loss impacting the lower body. In addition to major trauma, some reasons for acquired limb loss of the lower body include diabetes, neuropathy, and peripheral vascular disease leading to the need for surgical amputation(s). Individuals may also have limbs surgically amputated if they have cancer, localized infections, or excessive tissue damage. Trauma is the single most common cause of upper body limb loss. The most common cause of acquired limb loss in the United States is vascular disease, which impacts 54% of all individuals who have had a limb amputated. Trauma is the reason for 45% of acquired limb loss cases while cancer contributes to 2% of this population. More than half (65%) of all amputations are on the lower body. Within the category of vascular diseases leading to limb loss, diabetes is a significant concern. 85% of lower limb amputations occur after someone has an ulcer of the foot.

In the case of chronic conditions that may lead to limb loss, doctors may need to monitor someone over time to determine if amputation is necessary. Some risk factors for surgical amputation of a limb include persistent paresthesia or pain in that limb, non-healing or slow-healing wounds, a weakened or absent pulse in the limb, thickened nails at the end of the limb, gangrene, or shiny and overly smooth skin on the limb. These are all indications that amputation may be necessary.

Limb loss can also be described based on whether it impacts the upper or lower limbs. Upper limb loss may affect the fingers, wrist, or the arm while lower limb

loss may impact the toes, ankle, or leg. There are various terms for limb loss based on the upper and lower extremity level that is impacted.

### *Acquired Limb Loss: Lower Extremity Classifications*

- At-the-hip limb loss
    - Patient is lacking all of the thigh, knee, lower leg, foot, and toes. When an amputation is classified as at-the-hip, it's also known as hip disarticulation. This procedure involves separating the distal end of the pelvis from the femur.
- Above-knee limb loss
    - Patient is lacking some or all of the thigh along with the knee, lower leg, foot, and toes. When an amputation is classified as above-knee, it's also known as a transfemoral amputation. This procedure involves cutting through part of the femur.
- At-the-knee limb loss
    - Patient is lacking the lower leg, foot, and toes, but at least half of their patella is intact. When an amputation is classified as at-the-knee, it's also known as knee disarticulation. This procedure involves separating the distal end of the patella from the bones in the lower leg.
- Below-knee limb loss
    - Patient is lacking some or all of the lower leg along with the foot and toes, but their patella is fully intact. When an amputation is classified as below-knee, it's also known as a transtibial amputation. This procedure involves cutting through part of the tibia.
- Above-the-ankle limb loss

    - Patient is lacking some or all of the ankle along with the foot and toes. When an amputation is classified as above-the-ankle, it's known as a Syme amputation. This procedure involves cutting through part of the ankle joint.

- At-the-ankle limb loss
    - Patient is lacking the foot and toes, but at least half of their talocrural joint is intact. When an amputation is classified as at-the-ankle, it's also known as ankle disarticulation. This procedure involves separating the distal end of the ankle from the bones in the foot.

- Below-the-ankle limb loss
    - Patient is lacking some or all of the foot and toes, but their talocrural joint is fully intact. There are several types of below-the-ankle amputations and disarticulations. A Chopart amputation involves cutting directly below the ankle joint, leaving the heel and ankle intact. A Lisfranc disarticulation involves separating the base of the metatarsals from the tarsals. Transmetatarsal amputations involve cutting through the metatarsal bones.



### *Acquired Limb Loss: Upper Extremity Classifications*

- Above-the-shoulder limb loss
    - Patient is lacking the entire shoulder joint, elbow, forearm, wrist, and hand. When an amputation is classified as above-the-shoulder, it is known as a forequarter or interscapulothoracic amputation. This procedure involves removing the shoulder joint from its insertion points on both the scapula and the clavicle along with removing all soft tissue that connects the shoulder to the chest muscles.

- At-the-shoulder limb loss

    - Patient is lacking at least some of the shoulder joint along with the elbow, forearm, wrist, and hand. An at-the-shoulder amputation is also classified as a shoulder disarticulation since the procedure involves separating the shoulder joint from the scapula and clavicle. This procedure differs from a forequarter amputation in that tissues once connected to the chest and scapula remain and are secured at the glenoid cavity.

- Above-elbow limb loss
    - Patient is lacking some or all of the upper arm along with the elbow, forearm, wrist, and hand. An above-elbow amputation is known as a transhumeral amputation since it involves cutting through the humerus.

- At-the-elbow limb loss
    - Patient is lacking the forearm, wrist, and hand, but at least half of their elbow joint is intact. When an amputation is at-the-elbow, the procedure is known as elbow disarticulation, which involves surgically separating the end of the humerus from the bones of the forearm.

- Below-elbow limb loss
    - Patient is lacking some or all of the forearm, wrist, and hand, but their elbow joint is fully intact. When an amputation is below-elbow, the procedure is called a transradial amputation since surgeons must cut through part of the forearm bones (radius and ulna).

- At-the-wrist limb loss
    - Patient is lacking at least some of the wrist along with the hand. When an amputation is considered at-the-wrist, the procedure is also called wrist disarticulation since this refers to the surgical separation of the forearm bones from the hand.

- Partial hand limb loss
    - Patient is lacking some or all of their digits. Partial-hand amputations are also called transcarpal amputations since they involve cutting through the small bones of the wrist known as the carpals.

There is also some confusion about the difference between the terms ‘prosthetic’ and ‘prosthesis.’ Both ‘prosthetic’ and ‘prosthesis’ are defined as functional man-made devices worn in place of missing body parts. Each of these terms can stand alone and may even be used interchangeably. For example, someone can refer to an artificial leg as a prosthetic (plural: ‘prosthetics’) or a prosthesis (plural: ‘prostheses’). However, ‘prosthetic’ can function as a noun or an adjective, while ‘prosthesis’ is only a noun. This is why you’ll notice the word ‘prosthetic’ used in conjunction with specific body parts or the word ‘limb’ (e.g. prosthetic arm; prosthetic limb). The word ‘prosthetic’ may also refer to other medical devices such as dental implants and pacemakers. ‘Prosthetics’ is also the term for the branch of medicine that focuses on the design, development, and study of artificial limbs.

As mentioned earlier, prosthetics/prostheses are functional devices, so these terms are not used to describe artificial limbs used for cosmetic purposes. Individuals who opt for this type of device will receive a ‘cosmesis’ (plural: ‘cosmeses’). ‘Cosmesis’ may also refer to any procedure used to surgically correct severe scarring or other cosmetic defects resulting from an accident, injury, or disability.

## Section 1 Personal Reflection

What are some differences therapists may see in the diagnostic process for congenital limb reduction and acquired limb loss?

### Section 1 Key Words

Amputation - Disconnecting all or part of a limb from the body through a bone

Crush injury - Physical trauma that results from extended compression of the limbs, torso, or other body parts; depending on how long the body parts were compressed, someone with a crush injury can experience soft tissue, nerve, muscle, and bone damage of varying severities

Disarticulation - Disconnecting all or part of a limb from the body through a joint

Gangrene - A medical emergency that occurs when a large area of tissue loses its blood flow, which leads the tissue to breakdown and die off and can cause skin to turn greenish-black

Terminal segment - The most distal end of a limb; for example, the terminal segment of the arm is the hand



## Section 2: OT Evaluation for Limb Deficiencies

**References:** 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22

Regardless of the type of limb deficiencies a patient has, a comprehensive assessment is the first step to receiving occupational therapy. Firstly, therapists should gather the patient's medical history, either from them or via a thorough chart review. When evaluating patients with limb reduction, therapists will need to know about maternal or fetal health complications that arose during childbirth or other health concerns that are present. Some children born with limb deficiencies are diagnosed with chromosomal abnormalities, genetic conditions, or have general developmental delays, which all must be accounted for in the therapy process. There are a range of other factors that impact the evaluation process for those with congenital and acquired limb loss, so therapists should inquire about each of the following areas:

- Allergies
    - This can affect the type of surgical dressings, topical medications, and prosthetic materials used.
- Cardiac and vascular conditions
    - Occluded arteries, aneurysm repairs, and coronary artery bypass graft surgeries are all of note. In addition, therapists will need to know specifics of exploratory procedures with positive findings such as dopplers and angiographies. Each of these can impact healing if the patient has a residual limb.
- Cognitive ability related to managing the prosthetic limb (donning/doffing, using safely, keeping clean, etc.)
    - For patients with limb reduction, therapists should determine if the patient's family or caregivers have these abilities.
- Conditions that impact range of motion and strength, such as arthritis
- Diabetes and related complications such as pressure ulcers or neuropathy
    - Patients who have these conditions and underwent an amputation may require additional management due to surgical wounds not healing as quickly. In addition, the patient will likely be at risk of additional limb loss if these conditions are not managed.
    - Diabetes influences the circulatory system so patients who underwent an amputation may also experience additional sensory pathologies in the residual limb.
- Exercise tolerance and claudication
- Functional abilities in both the intact and residual limb, including ADLs, bed mobility, functional mobility with aid in various locations

    - This will be important in the rehabilitation process when the patient is fitted for a prosthetic.
    - Therapists should evaluate pediatric patients with limb reduction based on developmental milestones for their age.
- History of limb deterioration, also known as muscle wasting or atrophy
- History of physical trauma, joint surgeries, and other related surgeries
- Kidney function
    - Having a limb removed causes a major change in the interstitial fluid volume, which may temporarily impact kidney function. This is of concern for patients on dialysis or anyone who has diminished renal function.
- Skin condition, lymphatic drainage
- Sensation in residual limb
- Pain at rest
- Patient goals and expectations
    - Depending on the events leading up to an amputation, some patients (or their families) may view the procedure as a voluntary method to relieve their pain and improve their condition after a long illness. Other patients may have undergone amputations due to acute injuries or emergency scenarios, which may mean there was no time for counsel from a doctor about what happens next.
    - In either scenario, patients may not have a realistic picture of postoperative pain levels, their future functional status, how long rehab will take, the ease of using their prosthetic, the speed with which they receive a prosthetic, and more. Therapists will need to

identify these beliefs early on and offer education along with encouragement accordingly.

- Psychological adjustment
    - When discussing acquired limb loss, whether the procedure was expected or not, some patients need additional assistance adjusting to life after an amputation. Therapists should be aware of common reactions such as denial, projection, displaced anger, withdrawal, and regression that may impact the therapy process. If needed, therapists should be prepared to refer patients to behavioral health specialists for further support.
- Social history
    - Therapists should know who the patient lives with and whether they will be able to offer assistance as well as other sources of social support the patient can utilize.
    - The home environment is also an important part of the evaluation, so therapists should gather information about internal and external access (ingress/egress), layout, and if there is the possibility for a temporary or permanent first-floor setup.
    - In the case of acquired limb loss, an OT should determine how the amputation will impact the following aspects of the patient's job, if they are applicable: wheelchair accessibility of the work location, how much mobility is a part of their job, the commute to and from their job, timeline for returning to work after surgery, and adaptations that may be needed (either organizational or environmental in nature).
    - In addition, the evaluation should cover participation in leisure activities, hobbies, and driving. Therapists should refer patients to

driver rehabilitation specialists if this is a major priority for the patient.

- Vision and hearing
    - These functions play a large part in building someone's environmental awareness, which must be present in order to safely go about their daily activities with a prosthetic.
- Weight management
    - Patients with lower body amputations may need to be educated about the importance of managing their weight to relieve pressure on their residual limb and prosthetic. Therapists may need to give some basic information about modified exercises and diet changes to assist in the process, but should make referrals to a nutritionist if the patient is having a lot of trouble.



## Goals of Occupational Therapy Evaluation

There are several goals of an OT assessment for individuals with limb deficiencies. Of course, one of the primary goals is to create a treatment plan with strong consideration given to patient priority goal areas. The evaluation process also helps therapists prepare patients and their family or caregivers for what is to come in their medical plan of care (e.g. an amputation or fitting for a prosthetic, wheelchair, or other aid). This is especially pivotal and most effective if OTs and other rehab therapists are called in for services before a patient has an amputation or before they are fitted for a prosthetic. This also allows therapists to answer any questions these parties may have about prognosis and functional potential in the long term. In the case of amputations, therapists should explain that rehabilitation will likely take longer depending on how high the level of the amputation or limb deficiency is (e.g. someone who underwent a transfemoral

amputation will likely need more time to recover than someone with a foot amputation).

## Prosthetic Assessment

The OT assessment is also when a therapist will assess a patient for a wheelchair or a prosthetic limb and assist with pain management. When working with patients who have acquired limb loss, therapists should provide education surrounding phantom limb sensations and pain during the rehabilitation phase. In addition, it's never too early to discuss discharge planning for these same patients who are seen in inpatient facilities such as hospitals and skilled nursing facilities. This is because their discharge environment may no longer support their medical needs and therapists may need to make home modifications or seek an alternate discharge location.

Therapists must remember that the goal of occupational therapy with individuals who have limb deficiencies is to enable their independence regardless of whether they choose to wear a prosthetic or not. Therapists should use the following questions to engage patients in discussion and determine whether or not they are suitable for a prosthetic.



- If the patient has a lower body amputation, do they want to walk?
- If yes, is it medically and biomechanically possible for the patient to achieve their goal of walking?
    - For example, a patient with an above-knee amputation and a hip flexion contracture limiting them to 10 degrees of motion may not be able to safely use a prosthetic limb.
- What environments and terrains does the patient want or need to navigate?
- Will the patient experience enhanced quality of life as a result of the prosthetic?

In addition, the therapist must work together with the interprofessional team to determine if the patient's medical circumstances will accommodate a prosthetic. The team must consider the patient's level of amputation, the length and condition of the residual limb, the environments the patient will be part of after discharge, remaining comorbidities that may influence prosthetic use, and the patient's priorities for their care.

Some individuals may choose not to have a prosthetic for personal reasons, while others may be unable to wear a prosthetic because it's medically contraindicated. One study showed that veterans with peripheral artery disease (PAD), systemic sepsis, congestive heart failure (CHF), chronic kidney disease (CKD), psychosis, paralysis, metastatic cancer, and neurological conditions were all less likely to receive a prosthetic prescription after an amputation. This same study also found that younger individuals were more likely to request and comply with prosthetics than older individuals (specifically those over the age of 75). Therapists should be aware of the contraindications for prostheses:

- Poor hygiene
- Excessive perspiration
- Significant unresolved edema or fluctuating levels of edema in the residual limb
- Hypersensitivity in the residual limb
- Excess scar tissue in the residual limb, especially scar tissue that forms adhesions
- Significant unresolved phantom limb pain
- One or more non-healing or ulcerated wounds on the residual limb or very close to where a prosthetic would be placed

- Presence of invaginated scarring, which often results from wearing prosthetic that are a poor fit
- Being less than one year out from an amputation
    - Tissue settles quite a bit during the first year after an amputation, which may cause the shape and size of the residual limb to change drastically. This has a major impact on the fit of a prosthetic.
- Having an abnormal residual limb shape, including but not limited to a bulbous residual limb, which is characterized by a larger circumference distally than proximally
- Intolerance to full weight-bearing in the residual limb
- An allergic reaction to prosthetic materials
- Poor bone definition due to factors like obesity
- Wearing a silicone liner on the residual limb without a matrix (a layer intended to reduce friction), which can lead to elongation of the residual limb when it's under pressure
- Intolerance of pressure casting techniques prior to being considered for a prosthetic
- Difficulty donning and doffing due to concerns like large discrepancies between bony prominences
- Hyperextension, poor movement, or other motion-related concerns pertaining to residual limbs/joints
- Reduced proprioceptive input or tolerance to pressure on the residual limb
- Significantly impaired circulation in the residual limb
- Impaired sensation in muscles proximal to residual limb

- Lacking the ability to use some type of mobility device to ambulate within a set of parallel bars
    - As part of rehab with their prosthetic, patients will be expected to regularly walk the length of the parallel bars between 6 and 10 times per session.
- Impaired hand function preventing the patient from managing the prosthetic on their own
    - Depending on their particular device, patients with prosthetics will need to manage velcro pieces, straps, knee locking mechanisms, and other fasteners.
- Being unable to perform a stand-pivot transfer independently from a seat to their bed, toilet, and chair and back
- Lacking the strength to independently push themselves up from a seated position in a wheelchair to a standing position at parallel bars
    - This will impact their ability to participate in rehab with their prosthetic as well as their independence with transfers in the community.
- Being unable to stand between a set of parallel bars independently
    - Patients must assume a similar position for up to 5 minutes in order to be casted for a prosthetic.
- Lacking sufficient cognitive function
    - Specific skills that candidates for prosthetics must have are the ability to follow basic directions, process new information, and retain information over a long period of time.
- Certain comorbidities

- Since the residual limb must be in good shape for someone to be a candidate for a prosthetic, conditions such as rheumatoid arthritis and osteoarthritis are contraindicated. RA and OA both impact the joints, which means the patient will likely not have good bone structure to stabilize their prosthetic.
- In addition, conditions like chronic obstructive pulmonary disorder (COPD) and cardiac disease can significantly impact someone's endurance and exercise tolerance, which would preclude them from participating in prosthetic rehab.
- Patients with a history of stroke are far less likely to be referred for a prosthetic limb and associated rehab. Research shows this is often attributed to decreased activity tolerance. Specifically, far fewer individuals with a history of stroke were able to walk 30 meters without stopping compared to individuals without stroke. While prosthetic rehab gains are mostly the same between the two groups, many individuals with stroke have additional comorbidities that may prevent them from receiving a prosthetic.

For patients who cannot use a prosthetic limb, occupational therapy should focus on helping those individuals maintain or regain maximum independence with or without the help of other assistive devices.

## Wheelchair Assessment

Some individuals who undergo amputations and do not receive prosthetic limbs will need to be assessed for suitability in regards to a wheelchair. As part of a standard wheelchair evaluation, therapists must take the following measurements:

- Armrest height

    - The distance between the chair seat and the olecranon process located on the elbow. In terms of wheelchair sizing, therapists should add 1 inch to this measurement to allow the arm to rest at a comfortable angle.

- Backrest height
    - The distance between the chair seat and the patient's axilla. In terms of wheelchair sizing, therapists should subtract 4 inches from this measurement to allow space for adjustments depending on what part of the patient's back needs the most support.

- Footrest length
    - The distance between the patient's knees and the bottom of their feet. In terms of wheelchair sizing, therapists should subtract 1-2 inches from this measurement to allow the footplates to sufficiently clear the ground.

- Seat depth
    - The distance between the patient's posterior buttocks and the popliteal fold located just behind the knee. In terms of wheelchair sizing, therapists should add 2 inches to this measurement to avoid pressure on the back of the patient's knees.

- Seat height
    - The distance between the patient's heel and the popliteal fold. Patients who will self-propel their chair should be able to touch the floor with their heel. Patients who will rely on footrests for lower body support will need a slightly higher seat, as the footrests should be 2 inches from the floor.

- Seat width

    - The distance between the two widest points of the patient's hips, thighs, or buttocks. In terms of wheelchair sizing, therapists should add 1-2 inches to this measurement to avoid pressure on the patient's hips.

As with any wheelchair assessment, therapists should determine the factors that impact how a patient uses their wheelchair, including:

- What settings they will use the wheelchair in
- How many days of the week, hours of the day they will be in the wheelchair
- What purpose they will need the wheelchair to serve (e.g. allow them to be active/exercise/play sports, allow them to get from point A to point B, allow them to maintain a functional position to engage in occupations, etc.)
- How long the patient will need the wheelchair for

All of this information will be used to determine the type of wheelchair that is most appropriate for the patient. For example, let's say a patient who just underwent an above-the-ankle amputation wants a prosthetic and their medical team is in agreement with this decision. However, it's best practice for the patient to wait some time for the residual limb to properly heal and for the prosthetic to be fitted and created. As such, the patient only plans to use a wheelchair on an as-needed basis alongside crutches for a period of 1 year. In this case, the therapist may choose to explore pre-owned wheelchairs and make modifications that serve the patient for that time. If they cannot find one, the team may encourage the patient to use crutches to meet their needs and educate them on how to use them properly.

### *Wheelchair-Specific Considerations for Patients with Limb Deficiencies*

These standard measurements must be taken for patients to be fitted for a custom wheelchair of any kind. While these should also be taken for individuals with limb

deficiencies, there are a range of other factors therapists must account for when fitting such patients for a wheelchair. The first is pressure relief, which is crucial for any wheelchair user. However, pressure relief cushions should especially be a focal point of the evaluation process for patients who had limbs amputated due to diabetes. Diabetes causes impaired circulation and poor sensation, which places this population at a greater risk of pressure ulcers. These individuals may lack the body awareness that is a precursor to adjusting their position and relieving pressure. Therapists should also ensure that patients with limb deficiencies and diabetes are educated on how to care for their residual limb. Practices such as foot hygiene, foot inspection, skin checks on the whole body, and wearing proper footwear in a wheelchair can protect individuals from other complications such as infections. Individuals with limb deficiencies are likely to experience excess pressure in differing parts of the body due to their modified center of gravity. This means therapists and patients alike must check the entire body for signs of pressure rather than just the known locations such as the elbows and ankles. This practice is even more pivotal for patients with diabetes who have reduced sensation and may not be as attuned to what excess pressure feels like.

After fitting a patient for a wheelchair, therapists should also inspect the device closely to look for areas that may cause undue pressure on the residual limb. In many cases, therapists will need to remove or adjust certain parts of the wheelchair to accommodate cushions, bolsters, and other forms of support for those with limb deficiencies. Therapists should look at the wheelchair's backrest, footrest, and seat cushion to ensure they offer sufficient postural control, since these areas can easily contribute to patient fatigue if they are not supportive and adjusted according to the patient's body. If a patient will propel their own wheelchair, the backrest should be low enough so it doesn't interfere with scapula or shoulder movement. Structures such as this can limit their ability to reach and manipulate the wheel.

Anti-tip bars are another accessory wheelchair users with limb deficiencies may need. While wheelchairs for this population should be structurally adjusted to

avoid tipping, anti-tip bars are helpful in the early stages of rehab while someone is getting used to transferring to and from their wheelchair. Patients with high lower body amputations (at the hip level) or double amputations will have a different center of gravity than other wheelchair users. Therapists should move the wheelchair's axles further back (ideally behind the shoulders) to prevent tipping. The accessories and axle position can always be adjusted as patients become more confident with their chair. Wheelchair users with below-knee amputations who do not wear prosthetics should also be given stump boards so therapists can help reduce their risk of swelling, pressure ulcers, and contractures in the residual limb.

Wheelchair training (management, safety, propulsion, etc.) is another aspect of wheelchair use that should be modified for this population. For example, one of the most common propulsion methods for wheelchair users is the arc - involving a short stroke from the rear of the wheel to the highest point of the wheel. However, patients with limb deficiencies should be instructed to use long, circular push strokes because this offers better ergonomics. In addition, the shape of the semicircular stroke requires no extra hand movements and no quick directional changes. Wheelchair users with limb deficiencies should also simulate navigating various types of terrain, transferring across multiple surfaces, and managing obstacles such as curbs and steps in a way that promotes safety.

## Standardized Assessments

There are a range of outcome measures that can help therapists determine baseline levels and track progress for individuals with limb deficiencies. Many assessments that will help this population are functional in nature and focus on skills that may be impaired as a result of limb deficiencies. Technically, therapists can use any standardized assessments that measure skills such as balance, gait, coordination, strength, and motion. However, some well-known rehabilitation

assessments have been specifically tested for reliability with this population. These include:

- 2-minute Timed Walk Test (2MWT)
    - One study suggests this should be the first-line assessment for individuals with lower extremity amputation.
- 6-minute Timed Walk Test (6MWT)
- 10-meter Walk Test (10MWT)
- ABIL-HAND
- Activities-specific Balance Confidence Scale (ABC)
    - This has been tested as a reliable measure for those with lower extremity amputations who are in rehab learning to use their prosthetic.
- Berg Balance Scale
- Children's Hand Use Experience Questionnaire (CHEQ)
- Four Square Step Test (FSST)
- Frenchay Activities Index (FAI)
- Functional Mobility Scale
- Functional Reach Test (FRT)
    - A dated study suggests this can be helpful for patients who have a lower extremity amputation, but only if specific balance disorders are suspected.
- Locomotor Capabilities Index
- Narrowing Beam Walking Test (NBWT)

- Patient-Reported Outcomes Measurement Information System: Mobility tool (PROMIS Mobility)
- Timed Up and Go (TUG)
- University of New Brunswick Test of Prosthetic Function
    - The skill and spontaneity subscales have specifically been tested the most for use with those who have amputations.

In addition, there are several diagnosis-specific assessments therapists can use with individuals who have a history of amputations and other limb deficiencies. These have also been tested for reliability for certain points during a patient's rehabilitation journey:

- Amputee Activity Survey
- Amputee Mobility Predictor Without a Prosthesis (AMPnoPRO)
    - The reliability of this measure has been confirmed for use with patients who are post-amputation. There is another version of this same tool that is intended for use with patients who are participating in rehabilitation with their prosthetic.
    - This research also found that the AMPnoPRO has the best statistical predictor for motor ability.
- Atkins Prosthetic Functional Adaptation Rating Scale
- Basic Amputee Mobility Score (BAMS)
    - The reliability of this measure has been confirmed for use with patients who are post-amputation.
- Comprehensive High Activity Mobility Predictor (CHAMP)
- Houghton Scale

- Jebsen Taylor Hand Function Test (JHFT)
    - One study found sufficient validation data showing the JHFT is a useful tool for providers when comparing prosthetic devices for the upper extremity amputee population. This study also suggests using a broader range of methods when discerning who is appropriate for a prosthetic device, since scoring methods need to be a bit more sensitive to this population.
    - Specifically, the JHFT had a more proportional representation of bilateral and unilateral tasks for patients to complete than most other outcome measures.
- L-test of Functional Mobility for Adults with Lower Limb Amputations (L-test)
- Orthotic and Prosthetic User Survey (OPUS)
- Patient Assessment Validation Evaluation Test (PAVET)
- Prosthesis Evaluation Questionnaire (PEQ)
- Prosthetic Profile of the Amputee
- Rivermead Motor Assessment (RMA)
- The Activities Measure for Upper Limb Amputees (AMULA)
- The Box and Block Test (BBT)
    - The same study that determined validity for the JHFT with this population also found similar validation data for the BBT. This study also suggests using a broader range of methods when discerning who is appropriate for a prosthetic device, since scoring methods need to be a bit more sensitive to this population.

    - Specifically, the BBT had a more proportional representation of bilateral and unilateral tasks for patients to complete than most other outcome measures.
- Trinity Amputation and Prosthesis Experience Scale (TAPES)

Additional standardized assessments that may be helpful for this population include:

- 9-Hole Peg Test (9HPT)
- Assessment of Learning Process (ALP)
- Beck Depression Inventory
- Clinical Test of Sensory Interaction on Balance (CTSIB)
- Dallas Pain Questionnaire
- Disabilities of the Arm, Shoulder, and Hand (DASH)
- Fall Risk Assessment and Screening Tool (FRAST)
- Foot Tapping Test
- Functional Dexterity Test (FDT)
- General Health Questionnaire (GHQ)
- Hospital Anxiety Depression Scale
- Impact of Event Scale
- McGill Pain Questionnaire
- Modified Barthel Index (MBI)
- Modified Falls Efficacy Scale (MFES)
- Pediatric Balance Scale

- Pediatric Evaluation of Disability Inventory (PEDI)
- Pediatric Power Mobility Assessment
- Rosenberg Self-Esteem Scale
- Southampton Hand Assessment Procedure (SHAP)
- Symmetry in External Work (SEW) Measure
- The Assisting Hand Assessment (AHA)
- The Comprehensive Coordination Scale (CCS)
- The High-Level Mobility Assessment Tool (HiMAT)
- Upper Extremity Functional Index (UEFI)

Therapists must consistently address fall risk and psychological factors with individuals who have any type of limb deficiency. Individuals with amputations are specifically at a high risk of falls both before and after their surgery. However, there are several other factors that play into fall risk for this population. Prosthetic users who experience frequent falls in their home and within the community are typically younger, have better confidence in their balance, and experience injury as a result of their fall less often than prosthetic users in inpatient settings. One study found the incidence of falls to be around 8.37 per 1,000 days spent in an inpatient setting. This same study found just under 61% of acute rehab patients with lower limb amputations who had not yet received prosthetics experienced a fall during their hospital stay. Notable risk factors for falls among inpatient individuals include being between 41 and 50 years of age; having a history of stroke, amputation (specifically a unilateral transtibial amputation), and/or diabetes mellitus; and having 9 or more comorbidities. Individuals with bilateral amputations of any kind were found to have a decreased fall risk compared to individuals with unilateral amputations.

In addition, patients with limb loss have other risk factors for falls, including:

- Vascular dysfunction being a major contributing factor for limb amputation
- Having some form of cognitive impairment
- Being 70 years of age or older
- During the postoperative period, individuals with transtibial amputations are at the highest risk of falls
- During the rehabilitation period after an amputation, individuals with transfemoral amputations are at the highest risk of falls
- Having multiple prosthetics or complications related to their residual limb
- Being deaf or otherwise hearing impaired
- Undergoing an amputation less than 4 years ago
- Experiencing pain in the back or any other joint
- Having an amputation above the level of the knee, since this has a more significant impact on one's center of gravity
- Impaired sense of vibration
- Increased gait variability
- Exhibiting less caution when navigating stairs
- Demonstrating greater postural sway during ambulation compared to patients without amputations
    - This is especially prevalent in patients whose amputations were due to vascular dysfunction.
- Scoring very low or very high on outcomes measuring balance confidence and perception of one's balance

    - Individuals with limb loss most often experience a greater fear of falling when they have a history of falls in the last 12 months, have generally poor health, and must focus on each step as they take it.
    - Studies also show that excess confidence related to balance and walking abilities is a predictor of falls for individuals with lower limb amputations.

Some research suggests that including person-step exposure over time can clarify the risk of  injury and falls for individuals with limb loss. Another study found that 17.5% of community-dwelling individuals with lower limb loss had at least one injury related to a fall. 63.1% of individuals with lower limb loss had two or more falls in the past 12 months. Results also showed the majority of these individuals who fell were male, white, and had falls associated with ADLs, gait, ramps, or stairs. Females with lower limb loss had a greater likelihood of injury after a fall as did non-white individuals. People whose amputations were due to diabetes or peripheral artery disease were also more likely to sustain an injury after a fall compared to individuals without these precipitating conditions. Individuals with a history of transtibial amputation were also more likely to be injured after a fall compared to those who had transfemoral amputations.

Individuals with congenital limb deficiencies are equally as likely as individuals who undergo limb amputations to experience a psychological response to their condition. Since each person is different, there is no predefined time this response should last. However, such psychological responses stand to impact the person's mental health along with other factors that influence the therapy process, such as motivation, engagement, and planning. This is why it's essential that therapists address mental health during the evaluation process for limb deficiencies. Therapists should also be aware of the breadth of factors that can impact a person's psychological response:

- Age

- Economic and vocational variables
- In the event of amputation, reason for amputation may also play a part in the adjustment process (e.g. if the amputation was the end result of a long chronic illness that caused a lot of pain, someone may react less strongly)
- In the event of amputation, preparation prior to the procedure will impact the adjustment process (e.g. if the procedure was sudden or they felt they weren't given a choice about it, someone may react more strongly)
- Overall health status (e.g. presence of other health concerns)
- Personality style (e.g. individuals with narcissistic or perfectionistic traits may experience more difficulty than their peers)
- Presence of psychosocial support
- Prosthetic rehabilitation
- Surgical complications
- Team approach
- Vocational rehabilitation



## Section 2 Personal Reflection

What is the best way for an occupational therapist to approach the topic of mental health when evaluating a patient with limb deficiencies?

## Section 2 Key Words

Adhesions - Scar tissue and other fibrous materials that cause organs and tissues to stick to other internal surfaces; the formation of adhesions often happens naturally as the body heals after a procedure; however, adhesions can cause significant pain and other complications

Axilla - The space between the shoulder joint/upper arm and the torso; also called the armpit

Claudication - A temporary health concern that causes someone to experience pain when there is a lack of oxygen in their muscles; claudication is triggered by activity and managed with rest; other symptoms of claudication include discomfort and fatigue in the affected muscles (often the buttocks, hips, thighs, calves, or feet) when they are used

Interstitial fluid volume - The ongoing flow of fluid from the blood to the interstitium, which is the space between barriers and structures such as cell membranes, skin, and organs; the interstitial fluid contains elastin, various types of collagen, amino acids, and other liquids that provide the body's structures with oxygen and nutrients

Invaginated scarring - A type of scarring that occurs when an amputation-related wound folds in on itself due to excessive friction and pressure from a prosthetic during the healing process



## Section 3: OT Treatment for Limb Deficiencies

**References:** 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37

### Long-Term Outcomes for Patients with Limb Deficiencies

Before diving into occupational therapy treatment for individuals with limb deficiencies, therapists should be aware of the long-term outcomes for this population. Understandably, this will vary based on the category of limb deficiencies a patient has along with comorbidities they have and complications they have experienced.

The long-term outcomes are poorer for individuals who underwent limb amputations as a result of vascular conditions. Rathnayake et al. (2020) aimed to

determine the relationship between diabetic foot ulcers and related lower extremity amputations. Results showed that, after 1 year, the average rate of re-amputation was 20.14%. The rates of re-amputation after 3 and 5 years were 29.63% and 45.72% respectively. The average mortality rates among individuals with diabetic foot ulcers and a history of related lower body amputations were 13.62%, 30.25%, and 50.55% at the 1, 3, and 5-year marks respectively. These higher rates were also found to be associated with ischemic cardiomyopathy and re-amputation.

Over the past few decades, mortality rates have generally decreased for individuals with all types of amputations due to more advanced technology and greater management of complications such as infections. In particular, Beeson et al. (2023) found the first year mortality rates for individuals with lower limb amputations has decreased. However, 5-year mortality rates after these procedures are quite high and range from 40-70%. While peripheral artery disease and complications related to diabetes were closely related to higher mortality rates, simply having diabetes alone was not strongly linked to high mortality rates.

Melcer et al. (2019) dove deeper into a niche area within the population of amputations: veterans with amputations resulting from service injuries. This study looked at the long-term outcomes of veterans who sustained severe upper extremity injuries or underwent upper body amputations as a result of blast injuries. Results showed that veterans with both injury classifications experienced a high rate of psychological and physical health concerns immediately after the accident. The prevalence for wound complications related to the upper extremity injury decreased substantially after the first year as did the rate of psychological and physical health concerns. However, the occurrence of posttraumatic stress disorder increased from 20% in the first year to 36% in the third year. Statistics related to pain and other psychological disorders were relatively consistent across the 5-year-span – the prevalence of these conditions ranged from 69% to 90% during the first year and totaled between 37% and 53% during the fifth year. In comparison to the below-the-elbow amputation group and those who

experienced a severe arm injury but did not have an amputation, participants who underwent an above-elbow amputation were at a significantly higher risk of certain conditions. These included deep vein thrombosis, cervical pain, pulmonary embolism, obesity, mood disorders, osteoarthritis, and adjustment disorder. Specifically, the study found that below-the-elbow amputees were significantly less likely to experience osteomyelitis.

Shifting gears, Zuniga et al. (2021) looked at how upper limb prosthetics impacted the developmental trajectory of children with limb deficiencies. This study mostly focused on the childrens' dexterity and brain activity during their formative years. Results showed there were no major differences between dexterity in children with a prosthetic limb and children with a prosthetic simulator. These two groups did, however, demonstrate differences in brain laterality. The children who used prosthetic limbs showed more brain activation on the same side of the brain as the prosthetic limb was placed compared to the control group.

A qualitative international study by Chhina et al. (2021) looked at the health-related quality of life among children with lower limb deformities. Overall, the study found that participants experienced significantly impaired health-related quality of life compared to children without such deficiencies. These results were similar across all countries included in the study, and outcomes spanned social, physical, and psychological functioning.

In terms of congenital limb deficiencies, the majority of the research is surrounding prosthetic use and functional performance. However, there is also a fair deal of research on childrens' perceptions of their conditions. One qualitative study by Sjoberg et al. (2022) involved discussing views of childhood treatment with adolescents and young adults who have congenital limb deficiencies. Results showed that participants looked upon their limb reduction in a positive light with common themes including their condition creating opportunities for them, allowing them to choose their own path in life, and giving them a sense of belonging in certain contexts. In terms of their current situation, participants

mostly reported viewing their treatment as a continuous journey and that 'the door was left open' - though these views were with more of a neutral and slightly negative lens due to them not feeling childhood skills they learned were useful in the present. 'Closing a chapter' was another theme pertaining to current views because participants often reported non-compliance with their prosthetics and/or other assistive devices. In general, the study participants were split between uncertainty and confidence regarding their future with limb deficiencies.

A systematic review from Battraw et al. (2022) showed there are a variety of factors that influence and complicate a child's decision to wear a prosthetic limb after a congenital upper limb deficiency. The review found the most critical factor playing into upper body prosthetic limb use was whether or not it facilitated occupational performance and allowed the child to engage in healthy social interactions. The most common device recommended for this population is a prosthetic limb that is not cosmetically similar to a real human limb and has a single open-close grasp. Understandably, this lack of precision and poor appearance contribute to a child's perception of their device and ability to function. Battraw et al. also found that psychosocial quality of life is impacted by congenital limb deficiencies, specifically in the realms of independence, emotional health, school function, and social belonging. Participants across many studies also report that prosthetic limbs provide insufficient help in the area of physical functioning.

Maciver et al. (2023) found several predictors of quality of life in children and young adults who experienced limb loss. These predictors included: age, level of amputation, presence of phantom pain, candidacy for a prosthetic limb, gender, cause of amputation, remaining physical function, presence of depression and anxiety, body image, and type of prosthetic limb used. While this review found that younger individuals showed more resilience after limb loss than older individuals, researchers did not identify specific age groups that were more likely to adjust. Females demonstrated greater psychosocial adjustment to limb loss than males, but males adjusted better to activity limitations than females did.

## Occupational Therapy Treatment Areas for Limb Deficiencies

### *Treatment Models and Frames of Reference for Limb Deficiencies*

Since limb deficiencies have such a far-reaching impact on an individual's physical and psychosocial functioning, it's essential for occupational therapy treatment to cover all bases. Therapists creating treatment plans for those with limb deficiencies should use several foundations to structure their care. The Biomechanical frame of reference can help therapists identify the tangible impairments (such as range-of-motion and strength) that impact a patient's occupational performance in order to remediate them and assist with a patient's function. Biomechanical treatments are intended to prevent deterioration and restore motion wherever possible while compensating for any physical skills that cannot be restored. This frame of reference is typically combined with the Rehabilitative frame of reference, which focuses on compensating for impairments that will not respond to remediation and using a person's remaining abilities to encourage function.

In order to also address behavioral health, therapists should also use aspects of the Cognitive-Behavioral frame of reference and the Humanistic Model of Therapy. The first of these two can help individuals with limb deficiencies improve the automatic thoughts, beliefs, and core schemas that may be negatively impacting their performance. Treatments based on this frame of reference can include deep breathing exercises, systematic desensitization, and other treatments focused on anxiety, phobias, and depressive symptoms. Therapists may also assist patients in developing a graded activity schedule to help with chronic fatigue. While the Humanistic Model of Therapy cannot be used to directly structure therapeutic activities, it offers principles that should underlie all aspects of treatment. When working with individuals who have limb deficiencies, therapists should keep the three core conditions of Humanistic therapy in mind: empathy, congruence, and unconditional positive regard. The basis of this model is the belief that we all innately have the ability to psychologically grow and

achieve self-actualization under the right circumstances. By having Humanistic components in OT treatment, therapists can instill hope in their patients. Each of these models can be used to assist with various phases of rehabilitation for patients with any sort of limb deficiency.

### *Phases of Rehabilitation After Amputation*

Just as they would when treating conditions such as strokes and rotator cuff injuries, therapists should follow rehab protocols when working with patients who underwent an amputation. Such protocols advise therapists to prioritize specific goals for safety and best practice.

When working with patients who recently underwent an amputation, the first phase of rehabilitation entails the following goals regardless of the type of amputation a patient had:

- ADL modifications
    - Performing hygiene and self-feeding using adaptive equipment and other assistance as needed
- Desensitization
    - Tolerating tactile input on the residual limb
    - Engaging in home program for desensitization
- Education
    - Patient and family should be educated on what the rehab process will look like as well as details about the home program
    - Discussion about interest in a prosthetic limb
    - Information on their candidacy for a prosthetic limb, if applicable
- Fall prevention training

    - During the post-op period, patients with amputations - especially lower body amputations - are at a greater risk of falling due to changes in body awareness, a different center of gravity, and deconditioning.
    - Therapists can address this by offering neuromuscular reeducation and similar treatments to assist with improving balance, postural control, and symmetry of movement. If patients are using assistive devices, therapists should adjust them to the patient and educate them on proper use.
- Mental health
    - Asking questions about potential changes in body image and confidence
    - Screening for symptoms of depression
- Range-of-motion
    - Individuals with any level amputation should begin range-of-motion exercises as soon as the pain subsides or 7 days after surgery to prevent contractures and other complications
    - These exercises should prepare for attaining functional ROM in both extremities, including the one affected
    - Patients should be instructed about a home program focused on daily therapeutic exercise and postural control to assist with symmetrical movements
- Transfer and ambulation training (mostly for those with lower body amputations)
    - Depending on the level of the amputation and the person's upper and lower body strength, individuals recovering from lower body

amputations may utilize a stand pivot transfer, sliding board transfer, slide sheet, a forwards-backwards weight transfer, or a fully dependent transfer (using a Hoyer lift or other equipment).

- Wound management and care of the residual limb
    - Tolerating and assisting with scar massage
    - Good hygiene to keep the wound and limb itself free of infection
    - Visual inspections of the residual limb
    - Positioning to assist with preventing contractures
        - With lower limb amputations, discourage being seated or using a wheelchair for extended periods of time.
        - With lower limb amputations, whenever the patient is in bed, avoid placing a pillow under the residual limb. This will prevent hip flexion and can cause a contracture in a neutral position.
        - Individuals recovering from an above-the-knee amputation should be positioned in prone whenever possible. This prevents hip extension contractures. When placed in side-lying, someone with an above-the-knee amputation should lay on their unaffected side to prevent abduction on the recovering side. Therapists should also ensure horizontal orientation of the pelvis for AKA patients to prevent an abduction contracture.
        - Those recovering from a below-the-knee amputation should avoid having the knee flexed when sitting for prolonged periods. In wheelchairs and bed, these patients can utilize leg boards, leg rests, and knee immobilizers.

        - Avoid placing a pillow or other cushion under the residual limb for upper limb amputations.
        - Patients with any sort of foot amputation are at risk of an Equinus contracture. Those with a BKA are at risk of a knee flexion contracture while someone with an AKA may experience a hip abduction contracture, external rotation contracture, or a hip flexion contracture.
        - Individuals with forearm amputations are at a greater risk of an elbow flexion contracture and anyone with upper arm amputations may develop contractures in shoulder adduction, shoulder flexion, and internal rotation.
    - Elevating the residual limb, as appropriate, to prevent edema
    - Wearing a compressive limb wrap 24/7 on the residual limb that reaches above the most distal joint

During the second phase of rehab, which is about 2 or 3 weeks after surgery, a patient's goals typically become more specific. This is partly due to the delineation between those with upper limb amputations vs. lower limb amputations along with those who will receive a prosthetic vs. those who will not. At this time, patients will also engage in light strengthening exercises to assist with preventing contractures and enabling smoother movement. Individuals with upper body amputations who will receive a prosthetic may have goals such as using one-handed strategies for dressing, donning/doffing a compression garment, achieving in-hand manipulation in preparation for functional tasks, and using adaptive equipment to attain a functional grasp pattern assisting with grasping eating utensils and writing utensils.

### *Rehabilitation for Limb Deficiencies*

The rehabilitation process often looks different for patients with limb deficiencies. Because patients with limb deficiencies are born with these health concerns, their bodies often adapt to the limb loss more naturally. As a result, these patients do not always need extensive treatment as someone who underwent an amputation does. Orthotics such as splints and braces may be used in the early stages of development to assist with growth. Prosthetics are only recommended for these individuals if it will improve their function. Children with limb deficiencies may undergo surgery but, again, only if it will improve their function (e.g. help resolve or prevent complications). As mentioned earlier, many individuals adapt to life with limb loss and modify activities on their own in order to function in their natural contexts.

If a child does receive a lower body prosthetic, the limb will likely be given before they start walking since this assists with the acclimation process. Children who are fitted for upper body prosthetics receive them when they begin to sit unsupported since this can aid with postural control and symmetry.



### *Pain Management*

Individuals with any type of limb deficiency may experience pain, which stands to significantly impact a patient's engagement in occupational therapy. This is why pain management should be a primary focus of treatment for patients with limb deficiencies who report discomfort.

There are two main types of pain that can impact individuals with a history of amputation: residual limb pain and phantom limb pain. Residual limb pain affects the remaining part of a patient's limb after amputation while phantom limb pain feels as if the missing limb portion is hurting. Residual limb pain can be due to an infection, surgical trauma, nerve entrapment, neuropathy, or skin problems.

As long as patients do not have any open wounds and contraindications, OTs can use various physical agent modalities to assist with residual limb pain. Some treatment options for residual pain include: ultrasound, manual soft tissue massage, transcutaneous electrical nerve stimulation (TENS), acupuncture, acupressure, elastic wraps, and residual limb socks. In severe cases where anatomical structures or specific abnormalities are the cause of residual limb pain, patients may need to undergo additional surgery to relieve pain and reduce further complications. Early mobilization is one of the key ways to reduce pain after amputation, so be sure that range-of-motion-based treatments are incorporated as soon as the patient is medically cleared after surgery.

OTs must take a different approach for phantom limb pain, which is a type of chronic pain that results from misfiring neurons that are not attuned to the absence of a limb. Doctors may prescribe some medications such as anticonvulsants, antidepressants, muscle relaxers, opioids, and non-steroidal anti-inflammatory drugs (NSAIDs) to assist with this type of pain. However, there is more support for non-medication-related treatments. Some evidence-based treatments for phantom limb pain are similar to those for residual limb pain (such as acupuncture, massage, elastic wraps, and TENS). Due to the chronic nature of phantom limb pain, other modalities are also indicated: mirror therapy, biofeedback, virtual reality therapy, and guided imagery. Therapists can also assist with repositioning the residual limb with cushions or pillows to assist with visibility of the area. This method can help the brain generate appropriate signals that stop the pain at its source.

An OT-led study by Camacho et al. (2021) looked at trends surrounding occupational participation in those with lower limb amputations who experienced phantom limb pain. Results showed that, while the pain impacted occupational participation, it did not prevent engagement. Upon receiving OT focused on self-management and activity modifications to assist with phantom limb pain, individuals experienced greater participation levels. Social support and early

education were also strong predictors of improved outcomes related to phantom limb pain.

In addition, several OT researchers conducted preliminary research on the efficacy of combining transcranial direct current stimulation with mirror therapy for those with phantom limb pain. While this was a very small study, results showed there were no adverse side effects from the treatment and the patients experienced a notable decrease in pain levels.

### *Prosthetic Training*

A patient's goals for prosthetic training will vary depending on the type of prosthetic they have. However, some common goals for prosthetic training include:

- Adjusting certain prosthetic components (such as cables or harnesses)
- Donning and doffing the prosthetic
- Identifying parts of the prosthetic
- Performing daily limb inspections and hygiene
- Performing basic maintenance for the prosthetic such as cleaning it and keeping it dry (including but not limited to charging the battery and changing the battery - if applicable)
- Recalling and complying with their prosthetic wearing schedule
- Tolerating wearing the prosthetic for x hours per day
    - Therapists typically start patients with 1 hour per day across three different intervals and work their way up to 8 hours per day across three different intervals. After the first week of grading up the wearing time, patients should be able to wear the prosthetic continuously.

- Understanding when to contact their therapist or prosthetist regarding an issue with the prosthetic
- Using the prosthetic to engage in basic ADLs within a reasonable amount of time using an average amount of energy

Patients with prosthetic devices as a result of a transradial or transhumeral amputation might have some additional goals including:

- Changing the terminal device independently
- Closing and opening the terminal device through its full range of motion
- Closing and opening the terminal device to half, 1/3, and 3/4 of its range of motion
- Engaging in wrist flexion and wrist rotation with their prosthetic, if applicable to their device
- Presetting the terminal device without assistance

Some slightly different goals apply to individuals with prosthetic devices as a result of elbow disarticulation:

- Engaging the elbow in free swing
- Engaging in internal and external rotation using the device's turntable component
- Positioning the elbow at half, 1/3, and 3/4 of its range of motion with and without weight
- Presetting the elbow unit without assistance
- Simultaneously control the elbow unit and the terminal device
- Unlocking and locking the elbow unit of the device

In addition to the above goals, patients with prosthetic devices as a result of shoulder disarticulation or similar procedures will have some of the following goals:

- Engaging the shoulder in free swing
- Presetting the shoulder unit without assistance
- Unlocking and locking the shoulder unit

Literature suggests there is varied use of prosthetic devices among individuals with limb deficiencies. An OT-led study looked at the frequency of prosthetic use and utilization of OT services in individuals with upper limb deficiencies. Results showed that only 37.2% of the sample participated in OT in any setting for their condition. Additional investigation ruled out cost as a contributing factor for this decision. 42.3% of participants reported having and using a prosthetic limb at some point in their life. However, just 22% of these participants received OT specifically catered toward prosthetic training. It does seem that cost played a part in the remaining individuals' decision to get a prosthetic, as nearly 46% of participants expressed interest in a prosthetic device if it were affordable or entirely covered by insurance.

Since prosthetic rejection is a concern for individuals with upper limb prosthetics, occupational therapy research also explored the possibility of using video programs to improve patients' compliance and understanding about their device. Though this research simply suggests a potential framework and does not speak to the efficacy of the modality, various types of technology can assist with prosthetic training.

### *Environmental Modifications and Adaptive Equipment*

Home modifications and various pieces of equipment can help individuals with limb deficiencies achieve a greater level of independence. Some individuals with limb deficiencies will need to utilize a wheelchair, crutches, or other ambulatory

devices to get around their environment. Assistive devices that can help individuals with upper limb deficiencies include:

- Universal cuff
- One-handed food board
- Suction-cup meal preparation
- Rocker knife
- Roller knife/fork
- Bendable eating utensils
- Electric can opener
- Kettle tipper
- Tub transfer bench
- Bidet
- Raised toilet seat
- Non-slip mats both inside and outside the bathtub
- One-handed hair washer
- Handheld shower head
- Foot care kit
- Ez spray handle
- Bowl holder
- Pan turner
- Toothpaste dispenser

- Suction-cup brush
- Button hook
- Dressing stick
- Sock aid
- Button extender
- Elastic laces
- Zipper pull
- Shoe remover
- Velcro fasteners
- Lace tightener
- Wall switch extender
- Plug puller
- Furniture raisers/lifts
- Floor switch for appliances
- One-handed envelope opener
- Hands-free headset
- Easy glide writer
- Electric stapler
- Electric hole punch
- Adapted computer mouse
- Bladeless cutter

- Raised footrest for a desk
- Book holder
- Card holder
- Hands-free dog leash
- Automatic card shuffler
- Bowling ramp
- Clamp-on fishing rod

Suction cups and dycem are also excellent tools that can give individuals greater stability and control over their existing household objects. These can be lower-cost options for individuals who lack financial resources or sufficient insurance coverage to obtain some of the above assistive devices. In addition, home modifications can help this population. Therapists may want to help patients lower cabinets and shelves to allow for easier reach or shifting these items to a place that is more accessible. Therapists may also need to add railings to indoor and outdoor stairways along with ramps to home entrances. Depending on the available space, OTs may need to collaborate with a contractor to create a custom ramp. Contractors alongside OTs can also complete other home modifications such as doorway widening or installing off-set hinges to make doors more accessible for wheelchairs. OTs should install grab bars in places where individuals often transfer or slippery surfaces such as within the shower and near the toilet. In order to reduce the risk of injury, OTs should address home aspects such as lighting, clutter, exposed wires, and non-modifiable barriers. These can all increase the likelihood of falling for someone with a limb deficiency. Motion sensor lights are a great solution to enhance environmental lighting in a simple, low-effort manner.

### *Other Intervention Areas*

Occupational therapists are also well-positioned to assist with mental health concerns individuals with limb deficiencies may experience. OTs can address concerns such as impaired body image, symptoms of anxiety and depression, loss of confidence, and grief related to a change in or loss of occupational roles. Individuals experiencing difficulty adjusting to their limb deficiency can benefit from support groups, referrals to mental health professionals, leisure exploration, modified recreational activities such as adapted sports, and more.

Some individuals may feel unprepared or unable to work as a result of their condition, though this is more common with those who undergo amputations. In the case of amputation, therapists can intervene to assess a patient's work role and duties in preparation for modifying some tasks and engaging the patient in rehabilitation to improve their capacity for others. Patients with congenital limb deficiencies may require the same type of services but from a habilitative lens rather than a rehabilitative lens. One study found that patients with unilateral prosthetic hands who engaged in occupational therapy demonstrated improved self-efficacy at work, greater displays of psychosocial adjustment, and less discomfort overall.



There is a range of research supporting the utility of occupational therapy intervention for individuals with any type of limb deficiency. While treatment can vary quite a bit between limb reduction and limb loss through amputation, occupational therapy can greatly improve quality of life and occupational participation for this population.

## Section 3 Key Words

Acupressure - A complementary health approach that involves stimulating the same meridian points used in acupuncture; however, instead of stimulating these

points using small needles, acupressure involves tapping on the meridian points and points of pain with your finger

Free swing - In regards to a prosthetic limb, this is a neutral or disengaged position

Prosthetist - A professional who specializes in the fitting, customization, and maintenance of prosthetic limbs and similar devices

Terminal device - The end piece of a prosthetic limb; most prosthetic limbs can attach to a hook, a hand, or a prehensor that allows for finer grasping; most individuals take advantage of all three options and change them out depending on their activity of choice and personal preference

## Section 4: Case Study #1

A 12-month old child with congenital alexia of the right arm has been referred to OT due to concerns over her developmental progression. Per her doctor's assessment and parent reports, the child's gross motor skills and postural control are both age appropriate (per the doctor's assessment and parent and she can sit unsupported around 75% of the time. However, her doctor has some concerns about her fine motor skills and adaptive behavior specifically in relation to play exploration and early ADL participation. The child is otherwise healthy with no comorbidities to speak of.

1. How might OT help this child?
2. Is this child a good candidate for a prosthetic arm?
3. If so, when might this child be assessed and fitted for a prosthetic arm?
4. What goals might an OT focus on for this child?

## Section 5: Case Study #1 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. What is the first step the OT should take to help this child?

   Since there are reports that the child's developmental milestones may be delayed, the OT should first and foremost observe the child and complete an OT assessment. If the OT determines there are deficits, they can begin treating the child accordingly. The OT should also speak with the family as well as other members of the treatment team (doctor and PT, namely). This discussion should surround whether or not there is a medical need for a prosthetic and how the family feels about potentially using this device. The results of these conversations can inform treatment planning relative to pre-prosthetic training, so this should be done along with the evaluation.

2. Based on this information alone, does it seem like this child is a good candidate for a prosthetic arm?

   A child cannot be fitted for a prosthetic arm until they can assume and maintain unsupported sitting without help. This child can meet this objective around 75% of the time and is mostly on par with other gross motor milestones. As a result, this child will likely meet that goal either on her own or with a bit of rehabilitation. While it's too early to make a concrete decision about such a device based on a milestone the child has not yet achieved, it seems likely the child could benefit from a prosthetic.

3. If so, when might this child be assessed and fitted for a prosthetic arm?

   If the child hits her last gross motor milestone in a reasonable amount of time, she could be fitted for a prosthetic arm within the next year as long as the parents and medical team agree that it's a good idea. The one-year

timeline is important so the child can get accustomed to the arm while she is still developing and use it more naturally as time goes on.

4. What goals might an OT focus on for this child?

   Regardless of whether this child ends up with a prosthetic, OT should focus on mostly the same skills: fine motor dexterity in the child's typically-developing arm and adaptive skills related to play and ADL function. If the evaluation showed any concerns related to sensory integration, the therapist should incorporate sensory techniques wherever possible since there may be concerns related to bilateral integration.

## Section 6: Case Study #2

A 45-year-old male just underwent a shoulder disarticulation after a construction accident. He is single and struggling with the drastic change in body image. He has only ever worked in the construction industry and is also reporting some depressive symptoms related to not being able to work again. In addition, he is new to the area and says he does not have any family or friends in this state. When OT initially saw this patient for an evaluation, the therapist asked him about his goals if he were to participate in rehab. The patient replied, "I don't see the point in doing any of that. Nothing is ever going to be the same. I might as well not even be here." When the OT attempted to encourage the patient, he said he only wants a prosthetic arm but does not want to participate in any therapies. When the OT explained how the therapeutic process goes, the patient got angry and told her to leave and not come back.

1. What is the most important first step for the OT to take in this instance?
2. Is this patient a good candidate for OT?
3. What other members of the interprofessional team should the OT call in for this patient?

## Section 7: Case Study #2 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. What is the most important first step for the OT to take in this instance?

   Since the OT was not able to complete the evaluation, she should document the encounter and report that the patient is not willing to participate in therapy at this time. The OT should also make specific note of the patient's statements, which are passively suicidal. This is something that should be mentioned to the patient's doctor for further intervention.

2. Is this patient a good candidate for OT?

   The patient is not a good candidate for OT at this time for several reasons. His mental health is not stable enough to assure proper motivation for and participation in therapy. He is also under the wrong impression about the purpose of therapy. By stating he does not want rehab but does want a prosthetic arm, he demonstrates he is not willing to participate in the full plan of care and will likely not comply with proper usage and care for a prosthetic device. Lastly, the patient's anger and inability to listen to information the OT has to offer shows that he is not ready for therapy. An amputation will come along with a lot of new information and habit changes that a patient must be aware of.

3. What other members of the interprofessional team should the OT call in for this patient?

   The OT should discuss the encounter with this patient's doctor and recommend a referral to a behavioral health specialist. This is the only way for the patient to adjust to his new condition in a healthy way. In addition, this will be an important precursor to participation in rehab, which will be

important whether the patient gets a prosthetic limb or not. The OT should also be sure the patient is connected with a social worker. Since he has no support in this area, he will need care coordination and community resources to assist him, especially once he is discharged. The social worker can help with insurance approval and grant funding for major home modifications that may be needed along with in-home services and disability income.

## Section 8: Case Study #3

A 72-year-old female who is currently recovering from a knee disarticulation surgery is referred for an OT evaluation. This amputation was secondary to unmanaged diabetes. The patient has a generally positive outlook on her condition and is happy to engage with OT during the evaluation process. She reports adjusting well to the amputation. However, doctors state she is not aware of the growing need to manage her diabetes nor is she aware of the maintenance that will be associated with her residual limb. The patient reports no desire to have a prosthetic leg and states she is comfortable using a wheelchair to get around. She lives in a one-level home that she states is “already ready for a wheelchair.” She lives with her adult daughter and her son-in-law who both intermittently helped the patient leading up to the surgery. Her son-in-law works part-time and will be able to offer the most support following discharge. The patient most often plays cards and knits, which she says she was doing right up until her surgery without a problem.

1. Given the above information, what types of standardized tests might the OT want to perform as part of the evaluation?
2. The patient reports she is comfortable using a wheelchair after her surgery. What therapy concerns might arise based on this?

3. Based on the type of amputation this patient underwent, what goal areas should the therapist focus on?

4. What adaptive equipment or environmental modifications would this patient benefit from?

## Section 9: Case Study #3 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. Given the above information, what types of standardized tests might the OT want to perform as part of the evaluation?

   Since the patient is presenting with impaired awareness as to her condition, it's imperative that the therapist completes cognitive testing. Therapy for this level of amputation will either include prosthetic training or wheelchair training, and the patient must have intact cognition to safely and effectively engage in either. This limited awareness might also mean the patient is an unreliable historian, so the therapist should perform a functional assessment for ADLs. If possible, it would also help to conduct a health literacy screening to determine what type of information the patient does know about her condition(s). The results can help the OT modify future patient education, which should be a part of the treatment plan.

2. The patient reports she is comfortable using a wheelchair after her surgery. What therapy concerns might arise based on this?

   While it's good that the patient is comfortable with using an ambulatory device, the patient may be under the assumption that she can use a wheelchair in order to sidestep participation in rehabilitation. The therapist should respond to the patient's reports by stating that the therapy process

will help her engage in all activities more easily once she returns home. The therapist should offer education and encouragement along the way while emphasizing the importance of rehabilitation in remaining independent or engaging in preferred activities.

3. Based on the type of amputation this patient underwent, what goal areas should the therapist focus on?

   Transfer training (either with a slide board or using the stand-pivot method, depending on the patient's cognition and upper body strength) will be crucial as will wheelchair safety if that is the route the therapist and patient decide to go. The patient will need assistance with wound management to prevent edema, contractures, and infection. She will also need wheelchair modifications, namely adjusted axles to account for her new center of gravity and a pressure relief cushion (with indentations that accommodate the residual limb) to prevent bed sores. She would also benefit from intervention surrounding balance training, postural support, and functional mobility to assist with ADLs. OT has many opportunities to perform cotreatments with PT for a patient with this level of amputation.

4. What adaptive equipment or environmental modifications would this patient benefit from?

   This patient could benefit from a sock aid and long-handled shoe horn to help her with lower body dressing without the need for major postural adjustments. She could also use a long-handled sponge and soap-on-a-rope to assist with lower body bathing. She will need a long-handled mirror to help with skin checks on her residual limb and intact limb. Since she will likely be using a wheelchair, her home should be modified to accommodate this device. Modifications may include doorway widening, an exterior ramp, an indoor stair lift (if the patient's home is two-story and she is incorrectly reporting), a tub transfer bench, grab bars, and non-slip mats. The home

should also be prepared for wheelchair access and walkways should be cleared, hazards should be removed, and clutter should be stored safely.

## Section 10: Case Study #4

A 23-year-old male is 6 months out from an elbow disarticulation. This occurred due to a car accident leading to a crush injury. He has been diligently participating in therapy since the amputation. His wound is healing well and he takes good care of the residual limb. The patient has been following therapist recommendations for modified activities of daily living using one-handed techniques but receiving balance support and stabilization from his residual limb. He is experiencing improved pain management and has no complications. He is very motivated to be fitted for a prosthetic in the near future, as he would like to return to work as a package delivery driver.

1. Should the therapist re-evaluate the patient in preparation for a prosthetic limb? Why or why not?
2. Is it realistic for this patient to return to work as a delivery driver?



## Section 11: Case Study #4 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. Should the therapist re-evaluate the patient in preparation for a prosthetic limb? Why or why not?

   Yes, but the therapist should discuss the feasibility of a prosthetic limb with the patient's treatment team. The therapist should not give the patient false hope, as this can be detrimental. Once the team confirms he is a good

candidate for a prosthetic limb, the therapist can discuss this with the patient and revise his treatment plan with goals that will prepare him for the prosthetic.

2. Is it realistic for this patient to return to work as a delivery driver?

   Yes, the patient should be able to do this based on the given information. OT should work to further increase his upper body strength and ensure there is no postural asymmetry that could lead to injury. The OT can look more closely at the patient's job duties and develop a treatment plan based on skills the patient still needs to work on.

   If the OT is comfortable and trained in doing so, they can provide driver's rehabilitation services and offer modifications that can help this patient drive. Since the patient does not currently have a prosthetic, many vehicle modifications will involve operating functions with one hand. When the patient does get a prosthetic, these will be adjusted accordingly. For example, the patient can change out the terminal device on their prosthetic to a hook in order to utilize a steering wheel hook for turning capabilities.

   If the patient is not qualified to offer driver's rehab, they should refer the patient to a nearby program. The therapist can still provide services alongside driver's rehabilitation if they go with the latter option, since this will only complement the patient's progress.

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