

# Gülhane lower extremity amputee rehabilitation protocol: A nationwide, 123-year experience

Yasin Demir<sup>1</sup> , Koray Aydemir<sup>2</sup> 

<sup>1</sup>Department of Physical Medicine and Rehabilitation, University of Health Sciences, Gaziler Physical Therapy and Rehabilitation Training and Research Hospital, Ankara, Turkey

<sup>2</sup>Department of Physical Medicine and Rehabilitation, University of Health Sciences, Gülhane Faculty of Medicine, Gaziler Physical Therapy and Rehabilitation Training and Research Hospital, Ankara, Turkey

**Received:** October 18, 2020 **Accepted:** November 02, 2020 **Published online:** November 09, 2020

## ABSTRACT

Amputation, one of the oldest known surgical procedures, causes many physical, mental and sociological problems. With its 123 years of experience, Gülhane has a special knowledge and experience, particularly in amputation. The main purpose of this protocol is to reveal the steps to be followed in individuals with lower extremity amputation. In this way, it is aimed to create a resource which can be used by our colleagues who have difficulties in using an appropriate approach due to the lack of experience.

**Keywords:** Amputation, leg prosthesis, rehabilitation.

The establishment of the Physical Medicine and Rehabilitation Clinic coincides with the establishment of Gülhane Hospital. Founded in 1898, the clinic was first activated as a massage department. The management of the massage part of Gülhane was given to Dr. Hoffmann and his assistant Şemsettin Ateş, who was brought from Germany. Then, he was sent to Germany in 1908 and, when he returned, he became one of the founders of physical therapy. In 1933, an independent clinic under the name of Physical Therapy was established and became a separate specialty in the army. After the 1980s, with the increase in the number of patients with amputation caused by mines and explosives, the former Turkish Armed Forces Rehabilitation Center, with its new name Gaziler Physical Therapy and Rehabilitation Training and Research Hospital, gained experience in amputation rehabilitation. To document the experiences of many years in amputee rehabilitation, such a protocol was considered.<sup>[1]</sup>

Amputee rehabilitation should include a process aimed at ensuring the integrity of the body, performing the dynamic functions of the amputated limb, and regaining the role of the amputated individual in society. This process requires a multi-dimensional teamwork.<sup>[2]</sup> Prosthetic technologies, which have developed in recent years, and increased functional expectations in amputated individuals have made it necessary to implement a more effective rehabilitation program.<sup>[3]</sup>

A comprehensive and well-organized rehabilitation protocol consisting of stump care, positioning, exercise, prosthetic prescription, gait training, and functional therapy is of utmost importance for the functional use of prosthesis. Amputee rehabilitation protocol consists of four periods: (i) preoperative, (ii) postoperative and pre-prosthetic, (iii) prosthetic fitting, and (iv) social cohesion, vocational/sports rehabilitation and follow-up.

**Corresponding author:** Yasin Demir, MD. Sağlık Bilimleri Üniversitesi, Gaziler Fizik Tedavi ve Rehabilitasyon Eğitim ve Araştırma Hastanesi, Fiziksel Tıp ve Rehabilitasyon Kliniği, 06800 Çankaya, Ankara, Türkiye.

e-mail: dr\_yasindemir@yahoo.com

*Cite this article as:*

Demir Y, Aydemir K. Gülhane lower extremity amputee rehabilitation protocol: A nationwide, 123-year experience. Turk J Phys Med Rehab 2020;66(4):373-382.

## PREOPERATIVE PERIOD

Preoperative period is a part of the elective amputations and is not found in traumatic amputations. In this period, joint range of motion (ROM), muscle strength, and sensation should be assessed, and potential functional status should be predicted.<sup>[4]</sup> Patients should be informed about the prosthesis and the rehabilitation program to be applied, and prepared both physiologically and psychologically for the post-amputation period.<sup>[5-7]</sup> A detailed program to be applied in the preoperative period is shown in Table 1.

## POSTOPERATIVE AND PRE-PROSTHETIC TRAINING PERIOD

In this period, surgical wound care, pain, edema, positioning and preventing contracture and exercises are the main steps of rehabilitation program. In addition, joint ROM and muscle strength should be maintained, stump should be shaped, and early mobilization should be applied.<sup>[8]</sup> Education for daily living activities and psychosocial support should be provided to the individual and his family.<sup>[9]</sup> The recommended program for the postoperative period is shown in Table 2.

### Pain

Pain can have a catastrophic effect on the amputated individual; it may adversely affect the rehabilitation program and the use of prostheses, quality of life, return to work, and activities and social life. It is essential that effective pain control should be initiated in the perioperative period in amputated patients.<sup>[4]</sup> Therefore, effective analgesia should be provided at preoperative 48 h and postoperative 48 h. Opioids are the main pharmacological agents used in

pain control in the perioperative period. Many factors such as socket, suspension, and gait disturbances can be the cause of prosthetic pain. In case of pain during prosthesis use, all of these mechanical factors should be reviewed. The phantom sensation usually does not require treatment. Patients should be told that this feeling is normal and would fade away over time. This feeling can be sometimes uncomfortable and affect the patient's sleep, functions, and quality of life. In such cases, it should be treated similarly to neuropathic pain.

A multidisciplinary approach is essential in the treatment of phantom limb pain and residual limb pain.<sup>[10]</sup> In the treatment of these pathologies, non-pharmacological treatment methods including a wide variety of pharmacological and physical, behavioral, interventional-surgical treatments have been used. Although there are many treatment methods, there is no consensus on the optimal treatment regimen, and treatment success is low. In the first postoperative days, desensitization techniques such as massage, friction, and tapping are the initial steps in treatment. Pharmacological treatment should be considered, if desensitization techniques are insufficient and pain significantly impairs the patient's quality of life. Acetaminophen and non-steroidal anti-inflammatory drugs are among the most commonly used drugs. Other common and more effective pharmacological agents are antidepressants and anticonvulsants. The main advantages are that antidepressants are effective on depression, which is common in amputees, as well as pain. Anticonvulsants such as phenytoin, carbamazepine, oxcarbazepine, levetiracetam, gabapentin and pregabalin can be used in phantom pain. In cases where antidepressants and anticonvulsants are not effective, opioids can be used in the treatment of pain, considering the tolerance, dependence and

**TABLE 1**  
Preoperative rehabilitation program

- Informing the patient about the surgical intervention and rehabilitation program and psychological status afterwards
- Determining the functional status and questioning the co-morbidities
- Determining the potential of the patient to adapt to the rehabilitation program with a detailed examination and history
- Evaluation of cardiac and respiratory functions
- Physiotherapy
  - Joint range of motion
  - Stretching
  - Strengthening (lower extremity key muscles, trunk muscles)
  - Gait exercises without loading on the lower limb planned for amputation
  - Posture exercises
  - Respiratory and aerobic exercises

TABLE 2

## Postoperative and pre-prosthetic rehabilitation program

- Management of pain
  - Acute pain
    - Postoperative
    - Phantom sensation
    - Phantom pain
  - Chronic pain
    - Dysvascular
    - Neuroma
    - Residual limb pain
- Stump care
  - Suture control-wound care and follow-up
    - Intact skin on the residual limb
  - Prevention of skin and subcutaneous adhesion with massage
- Edema control
  - Bandaging
    - Elastic bandage
    - Removable casting
    - Fixed casting
    - Stump socks/compression socks/liner modifications
    - Rigid windings
  - Elevation
  - Temporary early prosthetic application
  - External pneumatic compression
  - Contrast bathrooms
  - Electrotherapy (interferential current, diadynamic current)
  - Positioning
- Functional therapy
  - In-bed activity
  - Transfers
  - Wheelchair use
  - Daily life activities
- Physiotherapy
  - Prevention of contracture
  - Protection of joint range of motion
  - Stretching
  - Strengthening
    - Isotonic exercises
    - Stump strengthening - gluteus medius, maximus, hamstring, quadriceps
    - Body core exercises
    - Uninvolved limb
    - Isokinetic follow-up
  - Mobility
    - Unsupported standing in parallel bar
    - Walking without prosthesis, with canadian (non-bilateral patients)
  - Balance
    - Sitting
    - Weight transfer while sitting
    - Standing up from a sitting position
    - Supported standing
    - Single limb standing balance
    - Exercises to load both lower limbs equally
  - Increasing aerobic capacity
    - Increasing respiratory capacity and strengthening the respiratory muscles
    - Endurance and condition
  - In-water exercise
- Recreational activity
- Desensitization exercises
- Cardiovascular follow-up
  - Heart rate, blood pressure
  - Reducing risk factors
- Patient education
- Emotional support

side effect profile. Relaxation techniques, biofeedback, transcutaneous electrical nerve stimulation, and mirror therapy are non-pharmacological modalities used to combat pain in amputated patients. In neuroma-induced pain, the socket should be reviewed primarily to relieve the pressure and the socket should be renewed.<sup>[11]</sup> If these methods fail, pharmacological agents for neuropathic pain, intralesional steroid and local anesthetic, alcohol, phenol injection, radiofrequency or cryotherapy may be beneficial. If all these treatment methods are ineffective, neuroma can be surgically excised.

### Edema

Surgical trauma, loss of bone, and muscle tissue creates dead space on the stump end, edema occurs with the effect of lymphatic dysfunction and gravity. Edema should be removed as soon as possible before applying permanent prosthetic fitting. For this purpose, methods that prevent edema formation and provide stump formation should be applied.<sup>[12]</sup> The main methods used to prevent edema and shape stump are elastic bandage, removable casting, fixed casting, stump socks, compression socks, liner modifications, and rigid windings. Elastic compression stockings, temporary prosthesis applications, stump elevation, contrast baths, exercise, electrotherapy (interventional and diadynamic current) and Jobst application are other methods used for edema control. Soft, semi-hard, and hard wraps can be also used for edema control in the postoperative period. An elastic bandage does not load the stump apex before wound healing is completed, while load transfer can be applied in the early period to reduce edema and shape the stump in hard and semi-hard applications. Wrapping

TABLE 3

## Principles of wrapping elastic bandage

1. Pressure should be reduced from distal to proximal
2. Should not restrict circulation and joint movements
3. Should be applied 2-3 times a day for 6-8 hours
4. When the prosthesis use is started, the bandage should be continued at night for at least one month
5. In the above knee amputations it should reach to waist level, should be applied in a standing or lateral lying position
6. For the below knee amputations it should be applied while the knee is extended, and in short stumps, the knee joint should also be enclosed in a bandage
7. Should cover all sides of the stump without bare area
8. Eight-shaped and spiral windings should be preferred
9. Bandages should often be washed with warm soapy water
10. Bandages with distorted elasticity should not be used

elastic bandage is the most common technique used as soft dressings. Bandage application should be started immediately, after sutures are removed. In the postoperative period, elastic bandages can be formed within six to eight weeks and postoperative prostheses can form stump within three to six weeks. Since the application technique requires skill, improper application can cause circulation problems and choke syndrome. Elastic bandage application principles are shown in Table 3 and figure-8 application technique is shown in Figure 1.

Constant pressure can be applied with a pneumatic splint for postoperative edema control; however, it is necessary to pay attention to its cleanliness due to heat and humidity. Pneumatic intermittent compression is started one to four weeks after amputation, 1 to 2 h a day and applied for one to four weeks. The applied pressure can be increased from 15 to 25 mmHg to 40 mmHg. The bandage of Unna, which is one of the semi-hard bandage applications, can be applied immediately after surgery and needs to be changed

every three to seven days. It is an effective bandaging method consisting of 10% zinc oxide, gelatin, calamine, glycerin and water, applying 18 to 24 mmHg pressure. However, easy relaxation is an important disadvantage of this type of bandaging.

In early-made cast socket, the body weight is transferred to the stump apex with the tube attached to the socket after the first week of amputation. By this way, edema and contracture are prevented, desensitization is provided, and proprioception is improved. However, the disadvantages of this method are that the stump remains in a closed and moist environment, it cannot be observed from the outside, and the application is not practical. Therefore, hard socket applications which can be worn in and removed every day in the early period after amputation are more preferred. Rigid socket applications provide effective edema control and allow stump inspections. It has been reported that both methods prevent edema, accelerate wound healing, prevent contracture formation, and shorten the initial prosthesis transition time.<sup>[13]</sup>



**Figure 1.** The figure showing how the 8-shaped bandaging is performed in a patient with below-knee amputation, respectively.

It has been also shown that cast socket applications are effective in removing stump edema, causing less pain, improving weight bearing, and increasing prosthetic fit, compared to elastic bandage.<sup>[13]</sup> Pneumatic compression applications provide early transition to initial prosthesis than elastic bandage.<sup>[14]</sup>

### Positioning and preventing contracture

The impaired balance of the agonist and antagonist muscles in an amputated limb contributes to the formation of joint contractures. Hip flexion, abduction, and external rotation contractures can be detected in patients with above-knee amputation.<sup>[10]</sup> Due to the loss of adductor muscles, the dominance of the hip abductors gradually increases. The loss of insertions and shortening of the hamstring muscles, which are the antagonists of the iliopsoas muscle, make the hip flexors more dominant. Normally, there is a three-time more force between the internal and external rotator muscles in favor of the external rotators. After amputation, the force of external rotators is shortened, tension and attraction on the muscle increase. Therefore, contractures occur faster in amputations with a shorter stump length.<sup>[11]</sup> In below-knee amputations, there is a tendency to flexion contracture in the knee joint. The hamstring muscle strength is more dominant than quadriceps. In addition, as a result of the elimination of the stabilizing effect of the gastrosoleus on the knee joint, the activity time of the hamstring muscles is prolonged.

Due to the pain, patients with lower limb amputation tend to keep the hip joint in the flexion, abduction and external rotation position, and the knee joint in the flexion position in the postoperative period. These positions should be avoided to prevent contracture formation. Lying on the edge of the bed in supine position, the hip joint should be stretched. Knee extension should be applied in addition to the hip extension in the below-knee amputation. Lying in a supine position, the stump should be supported to be straight and parallel to the other extremity, and it should be avoided to put a pillow under the knee joint and stump. Sitting in a wheelchair for a long time can cause flexion contracture in the hip. It is necessary to avoid putting a pillow between the legs, as it can cause abduction contracture in the hip. Patients with transtibial amputation should not sit for a long time in the knee-flexed position, putting a pillow under the knee and use of a wheelchair in a knee-flexion posture should be avoided. These positions result in flexion contracture in the knee joint, leading to functional

difficulties. Ambulation should be provided by early mobilization and temporary prosthesis application. To prevent hip flexion contractures; the patient should not lie on a soft bed, the head of the bed should not be raised, should not put a pillow under the thigh and waist while lying down, and a prone position should be recommended three times a day for 30 min.

### Exercises

The main goals of exercises in amputee rehabilitation are to maintain joint ROM and agonist-antagonist muscle strength balance, prevent atrophies, and increase cardiopulmonary capacity and exercise endurance. Consequently, the main aim is to be able to return to social life with the possible highest level of physical functions for an amputee.<sup>[15]</sup>

Exercise program should be started, if the medical condition is stable and the pain control is maintained from the first week. Joint ROM at the pain limit and isometric strengthening exercises should be started for the amputated limb and, then, strengthening of the intact limb and trunk muscles should be started. In-bed mobilization, transfers, and gait exercises without prosthesis should be started, if the patient's condition is stable.<sup>[16]</sup> In lower limb amputations, gait training with crutches should be started within one week.

In this period, due to pain and immobilization, breathing cycle deterioration and decreased cardiac effort capacity may be seen. Controlled breathing techniques are applied to correct impaired breathing. Strengthening the inspiratory and expiratory muscles and the auxiliary respiratory muscles provide an increase in respiratory efficiency and a decrease in energy consumption.

As a natural consequence of amputation, muscle groups should be strengthened, and endurance training should be given to perform the lost muscle strength and functions biomechanically.<sup>[17]</sup> For strengthening, less repetitive isotonic exercises against high resistance are suitable. To improve endurance, resistance should be decreased, and the number of repetitions and sets should be increased. For this purpose, ergometric aerobic exercises, sportive and recreational activities, in-water exercises, and swimming are recommended in suitable patients.

In patients with bilateral amputation, it is important to strengthen the core and proximal muscles and increase neurological control, regardless of the level of amputation.<sup>[18]</sup> Both the above-/below-the-knee amputee should

feel confident about the proximal hip muscles to maintain balance, as there is no foot and ankle control. Even upper extremity-amputated individuals need core strengthening for good prosthesis use and trunk stability. A rehabilitation program including the strengthening of transversus abdominus, rectus abdominus, obliquus abdominus, serratus, iliopsoas, gluteus, hamstring muscles, and back extensors and hip adductors should be started as early as possible to increase the success of rehabilitation.

Core muscles must be strengthened in all planes, including rotational movements, which have benefits to improve patient stabilization.<sup>[19]</sup> Since it is associated with a more normal prosthetic gait, hip extensor and abductor strengthening exercises should be emphasized.<sup>[20]</sup>

Similar to the use of stump in the prosthesis, closed kinetic chain body weight exercises are important. In individuals with lower limb amputation, it is important to carry out isokinetic evaluations to measure muscle strength objectively throughout the entire ROM and at constant speed in the early period and every two weeks, thereafter. The peak torque of hip flexor, extensor, and abductor muscle groups in the above-knee amputee, hip flexor, extensor, abductor muscle groups, as well as knee flexor and extensor muscle groups in the below-knee amputee should be measured at speeds of 30/60/90/120/180°/sec. The process of rehabilitation targets should be monitored, whether the targeted values are achieved or not, where necessary the objectives should be revised.

The human body's center of gravity, which is normally located just in front of the second sacral vertebra, is displaced due to amputation. In lower limb amputations, the center of gravity moves upward and to non-amputated side. Disruption of biomechanics causes disruption of static and dynamic balances. Improving balance and proprioception and increasing trunk stability are important for gait balance. Strengthening the abdominal and back muscles is necessary to ensure trunk stability.

Exercise programs should be arranged according to the level of amputation. In transfemoral amputations, flexion, external rotation and abduction contracture in the hip, and in the transtibial amputations, flexion contracture in the knee is frequently observed.<sup>[21]</sup> The imbalance between the agonist and antagonist muscles should be prevented by strengthening the internal rotator, extensor and adductor muscles of the hip. If there is contracture in any joint, stretching exercises

should be performed. According to the patient's general condition before stretching, pain due to stretching can be prevented by hot or cold applications. Among the proprioceptive neuromuscular stabilization exercises, rhythmic stabilization and hold-relaxation exercises can be applied.

## PROSTHETIC FITTING

It is extremely important to reveal the properties of the amputation and the needs of the individual before deciding on the prosthesis that the patient will use.<sup>[22]</sup> The patient's age, weight, profession, daily life and recreational activities, the length and shape of the stump, the condition of the bone and soft tissue, the strength of the stump muscles, cognitive status, and level of activity should be determined in advance.<sup>[23,24]</sup> After all, the prosthesis of the patient is decided at the team meeting where there is a physician, physiotherapist, orthopedist, prosthetist, social worker and most importantly the patient (Table 4).<sup>[25,26]</sup>

During the prosthetic education, attention should be paid to the hygiene of both the skin and the prosthetic materials which contact with the skin. Especially in the first prosthesis wearers, allergic contact dermatitis may be seen in the liner contact areas.

The prosthesis education process begins with the test socket and shank connection completed. This process includes; gait training, donning and doffing of prosthesis, weight transfer, balance-coordination, functional exercises and recreational activities.

The aim of gait training is to provide proper weight transfer to the prosthesis, to reduce energy expenditure during walking and to provide functionality in daily living activities.<sup>[27]</sup> Factors affecting gait training

**TABLE 4**  
Rehabilitation program for prosthetic period

- |  |
|--|
| <ul style="list-style-type: none"> <li>• Prosthetic prescription</li> <li>• Patient education             <ul style="list-style-type: none"> <li>- Frequent skin check</li> <li>- Management with skin problems</li> <li>- Hygiene</li> </ul> </li> <li>• Physiotherapy             <ul style="list-style-type: none"> <li>- Gait</li> <li>- To don and doff prosthesis</li> <li>- Weight loading</li> <li>- Balance-coordination</li> <li>- Functional exercises</li> <li>- Recreational exercises</li> </ul> </li> </ul> |
|--|

**TABLE 5**  
Follow-up program for amputees at K4 level

	Monthly assessment														
	1	3	6	9	12	18	24	36	48	60	72	84	96	108	120
PMR outpatient visit	X	X	X	X	X	X	X		X		X		X		X
<b>Biochemistry-microbiology</b>															
Complete blood count	X	X	X	X	X	X	X		X		X		X		X
Sedimentation	X	X	X	X	X	X	X		X		X		X		X
C-reactive protein	X	X	X	X	X	X	X		X		X		X		X
AST/ALT	X	X	X	X	X	X	X		X		X		X		X
Urea/creatinine	X	X	X	X	X	X	X		X		X		X		X
Uric acid	X	X	X	X	X	X	X		X		X		X		X
Creatine kinase	X	X	X	X	X	X	X		X		X		X		X
Albumin	X	X	X	X	X	X	X		X		X		X		X
ALP	X	X	X	X	X	X	X		X		X		X		X
Iron	X	X	X	X	X	X	X		X		X		X		X
Calcium	X	X	X	X	X	X	X		X		X		X		X
Ferritin	X	X	X	X	X	X	X		X		X		X		X
Vitamin B12	X		X		X		X		X		X		X		X
Vitamin D	X		X		X		X		X		X		X		X
Folat	X		X		X		X		X		X		X		X
TSH/T4 (thyroxine)	X		X		X		X		X		X		X		X
Urinalysis	X	X	X		X		X		X		X		X		X
Functional ambulatory category	X				X										
Barthel/FIM score	X				X										
Locomotor capabilities index	X				X		X		X		X		X		X
Houghton score	X				X		X		X		X		X		X
K-levels	X				X		X		X		X		X		X
<b>Radiology</b>															
Chest X-ray	X						X		X		X		X		X
Injury related x-rays	X	X	X	X	X		X		X		X		X		X
Ultrasound-soft tissue	X	X	X	X	X	X	X		X		X		X		X
<b>Other</b>															
Electrocardiogram	X						X		X		X		X		X
Bone mineral density					X						X				
Prosthetic assessment	X	X	X	X	X	X	X		X		X		X		X
Orthotic assessment	X	X	X	X	X	X	X		X		X		X		X
Pulmonary function test	X		X		X		X		X		X		X		X
EMG and NCS	X	X	X		X						X				
<b>Consultation</b>															
Psychiatry	X	X	X	X	X	X	X		X		X		X		X
Internal medicine	X		X		X		X		X		X		X		X
Cardiology	X		X		X		X		X		X		X		X
Urology	X		X		X		X		X		X		X		X
Chest diseases	X		X		X		X		X		X		X		X
Orthopedics	X	X	X	X	X	X	X		X		X		X		X
Diet	X	X	X	X	X	X	X		X		X		X		X
Neurology	X		X		X		X		X		X		X		X

PMR: Physical medicine and rehabilitation; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; ALP: Alkaline phosphatase; TSH: Thyroid-stimulating hormone; FIM: Functional independence measure; EMG: Electromyography; NCS: nerve conduction studies.

**TABLE 6**  
Follow-up program for K3 or lower level amputees

	Monthly assessment														
	1	3	6	9	12	18	24	36	48	60	72	84	96	108	120
PMR outpatient visit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<b>Biochemistry-microbiology</b>															
Complete blood count	X	X	X	X	X	X	X		X		X		X		X
Sedimentation	X	X	X	X	X	X	X		X		X		X		X
C-reactive protein	X	X	X	X	X	X	X		X		X		X		X
AST/ALT	X	X	X	X	X	X	X		X		X		X		X
Urea/creatinine	X	X	X	X	X	X	X		X		X		X		X
Uric acid	X	X	X	X	X	X	X		X		X		X		X
Creatine kinase	X	X	X	X	X	X	X		X		X		X		X
Albumin	X	X	X	X	X	X	X		X		X		X		X
ALP	X	X	X	X	X	X	X		X		X		X		X
Iron	X	X	X	X	X	X	X		X		X		X		X
Calcium	X	X	X	X	X	X	X		X		X		X		X
Ferritin	X	X	X	X	X	X	X		X		X		X		X
Vitamin B12	X		X		X		X		X		X		X		X
Vitamin D	X		X		X		X		X		X		X		X
Folat	X		X		X		X		X		X		X		X
TSH/T4 (thyroxine)	X		X		X		X		X		X		X		X
Urinalysis	X	X	X		X		X		X		X		X		X
Functional ambulatory category	X		X		X		X		X		X		X		X
Barthel/FIM score	X		X		X		X		X		X		X		X
Locomotor capabilities index	X		X		X		X	X	X	X	X	X	X	X	X
Houghton score	X		X		X		X	X	X	X	X	X	X	X	X
K-levels	X		X		X		X	X	X	X	X	X	X	X	X
<b>Radiology</b>															
Chest X-ray	X				X		X		X		X		X		X
Injury related x-rays	X	X	X	X	X	X	X		X		X		X		X
Ultrasound-soft tissue	X	X	X	X	X	X	X	X		X		X		X	
<b>Other</b>															
Electrocardiogram	X				X		X		X		X		X		
Bone mineral density					X		X		X		X		X		X
Prosthetic assessment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Orthotic assessment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pulmonary function test	X		X		X		X		X		X		X		X
EMG and NCS	X	X	X		X		X		X		X		X		X
<b>Consultation</b>															
Psychiatry	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Internal medicine	X		X		X		X		X		X		X		X
Cardiology	X		X		X		X		X		X		X		X
Urology	X		X		X		X		X		X		X		X
Chest diseases	X		X		X		X		X		X		X		X
Orthopedics	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diet	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Neurology	X		X		X		X		X		X		X		X

PMR: Physical medicine and rehabilitation; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; ALP: Alkaline phosphatase; TSH: Thyroid-stimulating hormone; FIM: Functional independence measure; EMG: Electromyography; NCS: nerve conduction studies.



include age, prosthetic components, amputation level, cause of amputation, muscle strength, and ROM.<sup>[28]</sup> Stump skin check in amputee who use prosthetics for the first time or have sensitive skin should be done after a 10-15 minutes walk. In the first week of gait training, some patients can wear the prosthesis for only an hour or two. Prosthesis use should be gradually increased in the following weeks.

### **SOCIAL COHESION, VOCATIONAL/SPORTS REHABILITATION AND FOLLOW-UP**

Patients should be encouraged to participate in sports and recreational activities suitable for amputees.<sup>[29]</sup> Individuals with amputations are at a higher risk for developing osteoarthritis, obesity, and cardiovascular disease.<sup>[30]</sup> By encouraging recreational activities, amputees can reduce the risk of these comorbidities. Recreational and leisure activities have a positive effect on individuals, both physically and socially. Daily physical activity has both extrinsic and intrinsic benefits for all.

Periodic evaluation of the patients should be performed according to the follow-up program of the Gülhane Lower Extremity Amputee Rehabilitation Protocol (Tables 5 and 6).

Various scales are used in the follow-up of the patient with lower limb amputation.<sup>[31]</sup> The most prominent features of these scales are that the patient can demonstrate their functional and endurance conditions as clearly as possible, it is practically feasible and reproducible.<sup>[32]</sup> The walking style of these patients, whether they use assistive devices, is assessed with functional ambulation scale and walking conditions are evaluated with 2-min walking test. Functional independence scale or Barthel index can be used in evaluating daily living activities. The amputee locomotor capacity index measures how patients evaluate their prosthetics functionally in daily life. The Houghton score can be preferred for the daily prosthetic wearing frequency. During follow-up, the patient's activity level should be re-evaluated, and the current prosthesis should match the activity level.<sup>[33]</sup>

#### **Acknowledgement**

We would like to thank all the rehabilitation team, including the chief physicians and our specialists, who contributed to the development of this protocol.

#### **Declaration of conflicting interests**

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

#### **Funding**

The authors received no financial support for the research and/or authorship of this article.

### **REFERENCES**

1. Available at: <http://gulhanetip.sbu.edu.tr/Akademik/FizikTedaviVeRehabilitasyonAnabilimDali> [Access date: November 06, 2020]
2. Sheehan TP, Gondo GC. Impact of limb loss in the United States. *Phys Med Rehabil Clin N Am* 2014;25:9-28.
3. Harvey ZT, Loomis GA, Mitsch S, Murphy IC, Griffin SC, Potter BK, et al. Advanced rehabilitation techniques for the multi-limb amputee. *J Surg Orthop Adv* 2012;21:50-7.
4. Dekker R, Hristova YV, Hijmans JM, Geertzen JHB. Pre-operative rehabilitation for dysvascular lower-limb amputee patients: A focus group study involving medical professionals. *PLoS One* 2018;13:e0204726.
5. Klarich J, Brueckner I. Amputee rehabilitation and preprosthetic care. *Phys Med Rehabil Clin N Am* 2014;25:75-91.
6. Belon HP, Vigoda DF. Emotional adaptation to limb loss. *Phys Med Rehabil Clin N Am* 2014;25:53-74.
7. Ali S, Fatima Haider SK. Psychological Adjustment To Amputation: Variations On The Bases Of Sex, Age And Cause Of Limb Loss. *J Ayub Med Coll Abbottabad* 2017;29:303-7.
8. Uustal H, Meier RH 3rd. Pain issues and treatment of the person with an amputation. *Phys Med Rehabil Clin N Am* 2014;25:45-52.
9. Pantera E, Pourtier-Piotte C, Bensoussan L, Coudeyre E. Patient education after amputation: systematic review and experts' opinions. *Ann Phys Rehabil Med* 2014;57:143-58.
10. Demey D. Post-amputation rehabilitation in an emergency crisis: from preoperative to the community. *Int Orthop* 2012;36:2003-5.
11. Shirota C, Simon AM, Kuiken TA. Transfemoral amputee recovery strategies following trips to their sound and prosthesis sides throughout swing phase. *J Neuroeng Rehabil* 2015;12:79.
12. Alsancak S, Köse SK, Altınkaynak H. Effect of elastic bandaging and prosthesis on the decrease in stump volume. *Acta Orthop Traumatol Turc* 2011;45:14-22.
13. Meier RH 3rd, Heckman JT. Principles of contemporary amputation rehabilitation in the United States, 2013. *Phys Med Rehabil Clin N Am* 2014;25:29-33.
14. Sanders JE, Fatone S. Residual limb volume change: systematic review of measurement and management. *J Rehabil Res Dev* 2011;48:949-86.
15. Wong CK, Ehrlich JE, Ersing JC, Maroldi NJ, Stevenson CE, Varca MJ. Exercise programs to improve gait performance in people with lower limb amputation: A systematic review. *Prosthet Orthot Int* 2016;40:8-17.
16. Littman AJ, Boyko EJ, Thompson ML, Haselkorn JK, Sangeorzan BJ, Arterburn DE. Physical activity barriers and enablers in older Veterans with lower-limb amputation. *J Rehabil Res Dev* 2014;51:895-906.
17. Yoo S. Complications following an amputation. *Phys Med Rehabil Clin N Am* 2014;25:169-78.
18. Wasser JG, Herman DC, Horodyski M, Zaremski JL, Tripp B, Page P, et al. Exercise intervention for unilateral amputees with low back pain: study protocol for a randomised, controlled trial. *Trials* 2017;18:630.

19. Shin MK, Yang HS, Yang HE, Kim DH, Ahn BR, Kwon H, et al. Effects of lumbar strengthening exercise in lower-limb amputees with chronic low back pain. *Ann Rehabil Med* 2018;42:59-66.
20. Nolan L. A training programme to improve hip strength in persons with lower limb amputation. *J Rehabil Med* 2012;44:241-8.
21. Meikle B, Devlin M, Garfinkel S. Interruptions to amputee rehabilitation. *Arch Phys Med Rehabil* 2002;83:1222-8.
22. Ennion L, Rhoda A. Roles and challenges of the multidisciplinary team involved in prosthetic rehabilitation, in a rural district in South Africa. *J Multidiscip Healthc* 2016;9:565-73.
23. Raya MA, Gailey RS, Gaunaud IA, Ganyard H, Knapp-Wood J, McDonough K, et al. Amputee mobility predictor-bilateral: a performance-based measure of mobility for people with bilateral lower-limb loss. *J Rehabil Res Dev* 2013;50:961-8.
24. Sions JM, Beisheim EH, Manal TJ, Smith SC, Horne JR, Sarlo FB. Differences in physical performance measures among patients with unilateral lower-limb amputations classified as functional level K3 versus K4. *Arch Phys Med Rehabil* 2018;99:1333-41.
25. Sansam K, O'Connor RJ, Neumann V, Bhakta B. Clinicians' perspectives on decision making in lower limb amputee rehabilitation. *J Rehabil Med* 2014;46:447-53.
26. Baars EC, Schrier E, Dijkstra PU, Geertzen JHB. Prosthesis satisfaction in lower limb amputees: A systematic review of associated factors and questionnaires. *Medicine (Baltimore)* 2018;97:e12296.
27. Kannenberg A, Zacharias B, Pröbsting E. Benefits of microprocessor-controlled prosthetic knees to limited community ambulators: systematic review. *J Rehabil Res Dev* 2014;51:1469-96.
28. Esquenazi A. Gait analysis in lower-limb amputation and prosthetic rehabilitation. *Phys Med Rehabil Clin N Am* 2014;25:153-67.
29. Kurichi JE, Ripley DC, Xie D, Kwong PL, Bates BE, Stineman MG. Factors associated with home discharge after rehabilitation among male veterans with lower extremity amputation. *PM R* 2013;5:408-17.
30. Robbins CB, Vreeman DJ, Sothmann MS, Wilson SL, Oldridge NB. A review of the long-term health outcomes associated with war-related amputation. *Mil Med* 2009;174:588-92.
31. Meier RH 3rd, Melton D. Ideal functional outcomes for amputation levels. *Phys Med Rehabil Clin N Am* 2014;25:199-212.
32. Heinemann AW, Connelly L, Ehrlich-Jones L, Fatone S. Outcome instruments for prosthetics: clinical applications. *Phys Med Rehabil Clin N Am* 2014;25:179-98.
33. Darter BJ, Hawley CE, Armstrong AJ, Avellone L, Wehman P. Factors influencing functional outcomes and return-to-work after amputation: A review of the literature. *J Occup Rehabil* 2018;28:656-65.