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Faculty of Physical Education and Sport

Physiotherapy Department

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Faculty of Physical Education and Sport

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Case study of Physiotherapy Treatment of a Patient with Transfemoral Amputation

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Prague, April 2023

Declaration

I declare that I am the sole author of this thesis has been written by myself, based on my clinical work placement in Nemocnice na Homolce. The writing was done according to the theoretical and practical knowledge I acquired while studying at the Faculty of Sport and Physical Education at Charles University.

I declare that no invasive methods were used during the clinical work placement, and the patient was duly informed about the procedures.

In Prague, April 2023, **Lucie Fiala**

Acknowledgments

I am grateful for the support of my family and friends throughout the journey of writing this bachelor thesis. Their encouragement and belief in me have been an endless source of strength and motivation.

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Physiotherapy is a field that requires not just technical expertise but also empathy and compassion towards patients. I am grateful to have gained a deeper understanding of the human body and its intricacies and for the opportunity to refine my skills in providing care to those who require it.

This (3rd) thesis marks the culmination of my journey as a student (finally), and I am excited to embark on the next phase of my career, knowing I am finally on the right path in life.

Once again, I extend my deepest gratitude to all those who have supported me on this journey and to the field of physiotherapy itself for offering endless growth opportunities, learning, and positively impacting people's lives.

Abstract (in Czech)

Autor: Lucie Fiala

Název: Kazuistika pacienta fyzioterapeutické péče o pacienta s diagnózou Transfemorální amputací

Cíle:

Tato práce je rozdělena do tří hlavních částí. První část poskytuje základní informace o amputaci dolní končetiny, včetně etiologie, prevalence, klinického obrazu, typů amputací dolní končetiny, protetiky, prognózy, komplikací a patokineziologie. Druhá část se věnuje fyzioterapii a rehabilitaci dolních končetin po amputaci a současným dostupným metodám léčby. Poslední část představuje kazuistiku provedenou v Nemocnici Na Homolce, včetně podrobného vyšetření, terapeutických zásahů, vyhodnocení výsledků a účinnosti terapie.

Metody:

Všechna vyšetření a terapie jsou založena na znalostech získaných na Fakultě tělesné výchovy a sportu Univerzity Karlovy. Mezi ně patří goniometrie, antropometrická měření, vyšetření držení těla a chůze a trénink, dechová sekvence, testy síly svalů a Jandovy pohybové stereotypy. Metody používané pro terapii pacienta byly především posilovací cvičení, protahování, terapie měkkých tkání a PIR. Nebyly použity žádné invazivní metody.

Hlavní cíle terapie bylo snížit bolest a otok, zlepšit pohyblivost, rovnováhu a koordinaci, posílit zbývající končetinu a okolní svaly, předejít sekundárním komplikaci (např. PLP, kontrakturám) a zlepšit držení těla a chůzi. Cílem bylo také zvýšit celkovou nezávislost a schopnost provádět základní činnosti denního života a podporovat celkové fyzické zdraví pacienta, aby mohl pokračovat v rehabilitaci s protetickým vybavením a tréninkem.

Výsledky:

Pacient absolvoval 16 terapeutických sezení, která objektivně i subjektivně řešila různé problémy, včetně bolesti, svalové síly, držení těla, chůze, pohybových vzorců, antropometrie, přesuny /mobility a dechová sekvence. Objektivní měření ukázala, že terapeutická sezení pozitivně ovlivnila fyzické zdraví pacienta. Naopak subjektivní měření významně zlepšilo duševní a emocionální pohodu pacienta.

Závěr:

Terapeutická sezení úspěšně zlepšila stav pacienta po amputaci dolní končetiny a omezeních zjištěných během původní kineziologického vyšetření. Strukturované, dosažitelné cíle a terapeutický plán přispěly k významnému pokroku, vedoucímu ke snížení bolesti, zlepšení sebedůvěry a zvýšení nezávislosti.

Klíčová slova: Fyzioterapie, Amputace dolní končetiny, Rehabilitace, Úvodní fáze

Abstract (in English)

Author: Lucie Fiala

Title: Case study of Physiotherapy Treatment of a Patient with Transfemoral Amputation

Objectives:

The thesis is structured in three main parts. The first part provides background information on lower limb amputations, covering the etiology, prevalence, clinical picture, etiology, prevalence, types of lower limb amputations, prosthetics, prognosis, complications, and patho-kinesiology. The second part covers the physiotherapy and rehabilitation that goes into lower limb amputations and currently available treatments. The final part presents a case study conducted at the Nemocnice na Homolce, including detailed examinations, therapy interventions, results evaluation, and therapy effectiveness.

Methods:

All examinations and treatments are based on the knowledge I have acquired in the Faculty of Physical Education and Sports of Charles University. These include goniometry, anthropometric measurements, posture and gait examinations and training, breathing pattern, muscle strength tests, and movement pattern. The methods used for the patient therapy were primarily strengthening exercises, stretching, soft tissue therapy, and PIR. No invasive methods were used.

The main goals of the therapy were to reduce the pain and edema, improve mobility, balance, and coordination, strengthen the residual limb and surrounding muscles, prevent secondary contractures (e.g., PLP, contractures), and improve posture and gait. To increase overall independence and ability to do ADLs and promote overall physical health so that the patient can continue rehabilitation with prosthetic fitting and training.

Results:

The patient underwent 16 therapy sessions that objectively and subjectively addressed various issues, including pain, muscle strength, posture, gait, movement patterns, anthropometrics, transfers/mobility, and breathing patterns. Objective measures indicated that the therapy sessions positively impacted the patient's physical health. In contrast, subjective measures significantly improved the patient's mental and emotional well-being.

Conclusion:

The therapy sessions successfully improved the patient's condition after a Lower Limb Amputation and the limitations found during the initial kinesiological examination. In addition, the structured, achievable goals and therapy plan contributed to significant progress, leading to reduced pain, improved confidence, and increased independence.

Keywords: Physiotherapy, Lower Limb Amputation, Rehabilitation, Early Phase

Abbreviations

ABD = Abduction

ACL = Anterior cruciate ligament

ADD = Adduction

ADLs = Activities of daily living

AROM = Active range of motion

BPM = Beats per minute

COG = Center of gravity

CV = Cardiovascular

ER = External rotation

EV = Eversion

EXT = Extension

FLX = Flexion

INV = Inversion

ITB = Iliotibial Band

IR = Internal rotation

L3, L4 = Lumbar spine vertebrae 3 and 4

LBP = Low back pain

LCL = Lateral cruciate ligament

LLA = Lower limb amputation

MCL = Medial cruciate ligament

NS = Nervous system

PCL = Posterior cruciate ligament

PIR = Post-isometric relaxation

PLP = Phantom limb pain

POV = Point of view

PVD = Peripheral vascular disease

ROM = Range of motion

SCM = Strenocleidomastoid

TFL = Tensor Fascia Latae

Table of Contents

Table of Contents 1

1. Background information 4

1.1 Introduction 4

1.2 Etiogenesis of LLA 5

1.2.1 Causes and prevalence 5

1.2.2 Incidence 6

1.2.3 Clinical picture and symptoms 7

1.3 Types of LLA 8

1.3.1 Hip disarticulation 9

1.3.2 Transfemoral 9

1.3.3 Knee disarticulation 10

1.3.4 Transtibial 10

1.3.5 Ankle disarticulation (Symes) 11

1.3.6 Mid tarsal (Chopart/ Lisfranc) 11

1.3.7 Digits 12

1.4 LLA prosthetics 13

1.4.1 Goals 13

1.4.2 Types of LLA prosthetics 14

1.4.3 Biomechanics of LLA prosthetics 16

1.4.4 LLA prosthetic fitting and process 17

1.4.5 Complications 17

1.4.6 Eligibility 18

1.5 Stages of LLA 19

1.5.1 Pre-operation 19

1.5.2 Operation 20

1.5.2.1 Contraindications 20

1.5.3 Post-operation 21

1.5.4 Prosthetic 22

1.6 Prognosis 23

1.7 Complications 24

1.8 Patho-kinesiology of LLA 28

2. Physiotherapy and rehabilitation in LLA 34
2.1 Physiotherapy goals 34
2.1.1 Pre-operation 34
2.1.2 Post-operation 34
2.1.3 Prosthetic 35
2.1.4 Challenges 35
2.2 How to reach rehabilitation goals 36
2.3 Current treatment approaches 38
3. Special part – Case Study 40
3.1 Methodology of work 40
3.2 Initial kinesiological examination 41
3.2.1 Status praesens 41
3.2.2 Anamnesis 42
3.2.3 Additional data – first therapy unit 43
3.2.4 Additional data – second therapy unit 47
3.2.5 Additional data – third therapy unit 48
3.2.6 Additional data – fourth therapy unit 49
3.2.7 Additional data – fifth therapy unit 50
3.2.8 Exam conclusion 51
3.3 Short and long-term physiotherapy plan 54
3.4 Daily record of the therapy process 55
3.4.1 First Therapy Unit 55
3.4.2 Second Therapy Unit 57
3.4.3 Third Therapy Unit 59
3.4.4 Fourth Therapy Unit 62
3.4.5 Fifth Therapy Unit 65
3.4.6 Sixth Therapy Unit 68
3.4.7 Seventh Therapy Unit 71
3.4.8 Eighth Therapy Unit 74
3.4.9 Ninth Therapy Unit 77
3.4.10 Tenth Therapy Unit 79
3.4.11 Eleventh Therapy Unit 81
3.4.12 Twelfth Therapy Unit 83

3.4.13 Thirteenth Therapy Unit 85
3.4.14 Fourteenth Therapy Unit 87
3.4.15 Fifteenth Therapy Unit 89
3.4.16 Sixteenth Therapy Unit 91
3.5 Final Kinesiological examination 93
3.5.1 Exam conclusion 98
3.6 Evaluation of the effect of therapy 100
3.6.1 Summary of Therapy Effectiveness 106
3.6.2 Prognosis 106
3.7 Discussion 107
3.8 Conclusion 109
4. Bibliography 110
5. Annexes 118
5.1 List of Tables 118
5.2 List of Images 119
5.3 Model informed consent 120
5.4 Application for Approval by UK FTVS Ethics Committe 121

1. Background Information

1.1 Introduction

An amputation is a complex surgical procedure in which a part or the whole limb is removed (*Esquenazi and Yoo, 2016*), significantly impacting the individual's physical, emotional, and social well-being. In addition, rehabilitation is a long process to regain mobility and independence, and many may face challenges during their recovery journey.

An amputation can be "major" or "minor," depending on at what level the surgery takes place. For instance, a minor amputation would be considered anywhere near the ankle joint. (*Godlwana, Nadasan and Puckree, 2008*). This type of surgery is usually a result of severe and non-treatable conditions affecting the limb.

This study will focus on lower limb amputations (LLA). This bachelor thesis examines the early rehabilitation stage following an LLA and explores its impact on the individual's physical, emotional, and social well-being outcomes. In addition, this study aims to gain a deeper understanding of the challenges faced during the early rehabilitation stage and identify best practices for optimizing outcomes for individuals post-LLA. The case study was conducted at Nemocnice na Homolce between 06.01.2023 – 27.01.2023, starting one-day post-surgery.

1.2 Etiogenesis of LLA

1.2.1 Causes and prevalence

Lower limb amputation is typically performed due to medical conditions such as (*Marshal and Stansby, 2008; Molina and Faulk, 2021*):

1. Peripheral artery/ vascular disease – most common cause
2. Diabetes mellitus/ diabetic peripheral neuropathy
3. Trauma
4. Cancer
5. Chronic infections
6. Wounds that do not heal
    - Cannot restore blood flow
    - Infections leading to septic shock
    - wet gangrene = infected necrosis resulting in sepsis
    - dry gangrene = ischemic necrosis
7. Neuromuscular disorders
8. Vascular malformations
9. Congenital limb defects

It is a serious surgery performed as a last resort for patients with severe conditions that do not have many other options or as a preventative measure to avoid infection spread or to prevent further limb damage.

The prevalence of lower limb amputation varies globally, with higher rates in older populations and those with certain underlying medical conditions, most commonly those with diabetes and peripheral artery disease. According to the World Health Organization (WHO), approximately 30-40 million people have amputations worldwide, with 80% of these being lower limb amputations.

1.2.2 Incidence

Incidence of LLA is the frequency of new cases in a population over a given period and can vary based on location and demographic. In developed countries, the leading causes of non-traumatic LLA are caused by diabetic complications such as foot ulcers (and peripheral necrosis or peripheral vascular disease. Risk factors for LLA *(Godlwana, Nadasan, and Puckree, 2008):*

1. Males
2. Aging – e.g., PVD risk increases with age.
3. Obesity – e.g., PVD risk and foot complications increase; therefore, LLA risk increases.
4. (Duration of) diabetes mellitus – people with diabetes have a 30x more significant risk of having an amputation compared to non-diabetics (*Molina and Faulk, 2021*)
5. Peripheral Vascular disease (PVD) – leads to poor circulation in the limbs, increasing LLA risk.
6. Other co-morbidities
7. Smoking – a risk for PVD and linked to neuropathy

1.2.3 Clinical picture and symptoms

The clinical picture and symptoms of a lower limb amputation can vary depending on the level of the amputation and individual circumstances, but some standard features include (*Becker et al., 2011*):

1. **Pain**: Often occurs at the amputation site and may persist for some time post-surgery
2. **Stump/ residual limb management**: Involves ensuring proper wound healing, preventing infections, and managing pain
3. **Phantom limb pain**: The sensations of pain, itching, or burning in the missing limb (*MacLachlan and Hallam, 2011*)
4. **Prosthetic fitting and use**: may be necessary for individuals with LLA. The goal of prosthetics is to help the individual resume normal activities and improve mobility (*van der Meijden et al., 2008*)
5. **Psychological effects**: Amputation affects an individual's physical, mental, and emotional well-being. Horgan and MacLachlan (2004) reported high levels of depression and anxiety two years after surgery. In addition, LLA patients experience high social discomfort and body image anxiety. However, several factors can contribute to positive adjustment to LLA, such as (*Morgan and MacLachlan, 2004; Dunne et al., 2014*):
   - having strong social support
   - satisfaction with the prosthesis
   - longer time passed since the surgery
   - lower-level amputation
   - a disposition towards a more optimistic personality
   - Having a leisure activity that can help regain a sense of normality

After a LLA, the body compensates for the missing limb or the limitations of a prosthesis by adapting joint alignment and soft tissue to new postures, for instance, a postural shift after a lower limb amputation, which can lead to uncoordinated muscle movement and difficulty moving safely. This can cause pain, increased energy expenditure, and loss of confidence in one's movement due to the change in biomechanics. Restoration of proper mid-line alignment can help with more efficient muscle use (*Gaunaurd et al., 2011; Ku et al., 2011*)

1.3 Types of LLA

There are numerous types of amputations depending on the condition of the patient and the location of the lower extremity (*Godlwana, Nadasan, and Puckree, 2008: Murphy, 2014*; *Robinson et al., 2010*; *Molina and Faulk, 2021; Martini, Timmons and Tallitsch., 2018; Netter., 2019*):

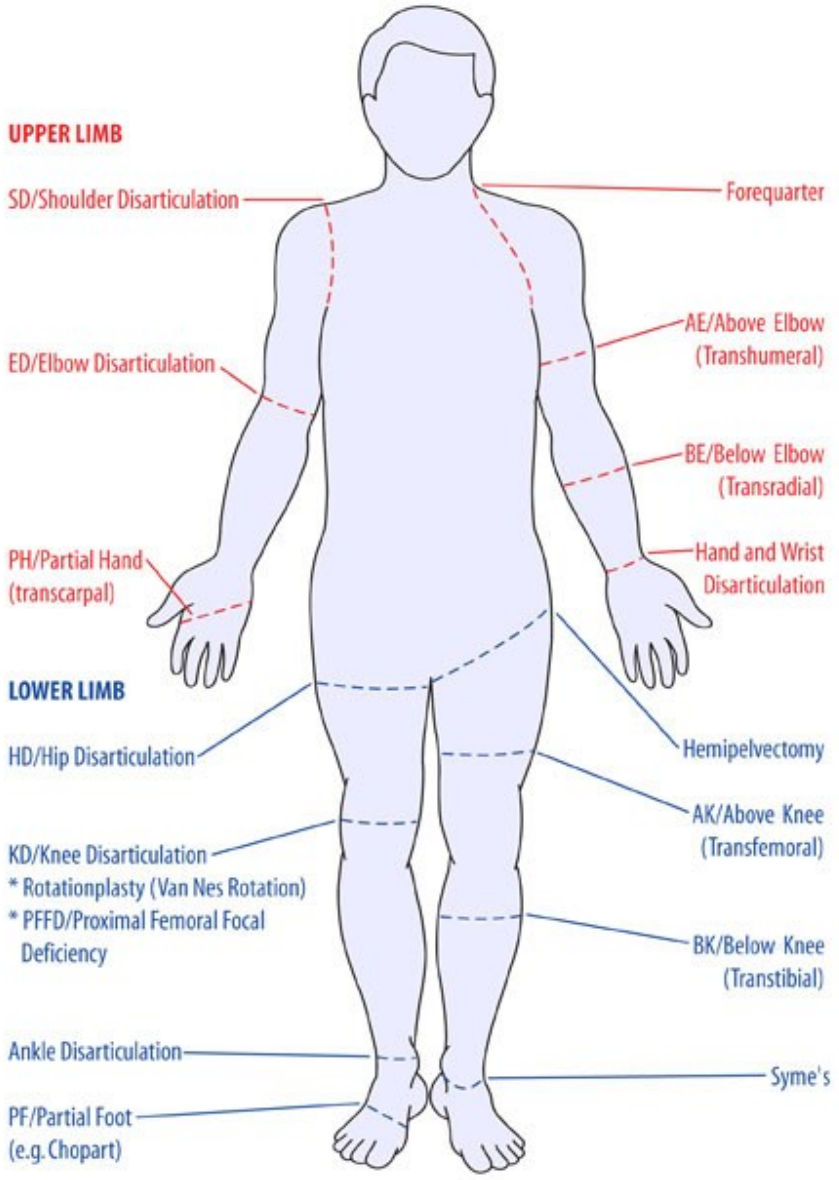

Image 1: Illustration of different amputation levels, taken from Physiopedia. (2021)

1.3.1 Hip disarticulation

- **Location:** at the hip
- **Anatomical changes:**
  - The femur is separated from the acetabulum
  - The muscles, veins, and nerves that are connected are severed and removed along with the femur:
    - *Gluteus maximus, Adductors, Hamstrings and Quadriceps*
    - *Femoral vein*
    - *Femoral nerve, Sciatic nerve, and Obturator nerve*

1.3.2 Transfemoral

- **Location:** above the knee
- **Anatomical changes:**
  - Commonly 25-30cm below the greater trochanter, removing the leg above the knee joint
  - The muscles, veins, and nerves that are connected are severed or removed are
    - *Quadriceps, Adductors, and Hamstrings*
    - *Femoral vein* – is usually tied off and divided
    - *The femoral nerve and Sciatic nerve* – may be cut or damaged, resulting in numbness or weakness in the affected limb

1.3.3 Knee disarticulation

- **Location:** at the knee
- **Anatomical changes:**
  - Removal of the entire knee joint and surrounding tissues
  - The bones removed:
    - *Femur, tibia, fibula, and patella*
  - The transaction of several muscles, nerves, and blood vessels results in significant functional and sensational changes in the residual limb:
    - *Quadriceps, Hamstrings, and Gastrocnemius and Soleus* – transection of the Quadriceps and Hamstrings causes significant weakness and loss of function in the residual leg and affects the ability to perform specific movements such as bending or squatting
    - *Popliteal vein and other small veins* – affect blood flow and drainage in the residual limb
    - *Femoral nerve, Sciatic nerve, and Saphenous nerve*

1.3.4 Trans tibial

- **Location:** below the knee
- **Anatomical changes:**
  - Commonly done 11-12cm distally, removing the lower leg below the knee joint
  - The transection of several muscles, nerves, and blood vessels results in significant functional and sensational changes in the residual limb:
    - *Tibialis anterior, Peroneal muscles, Gastrocnemius, and Soleus*
    - *Popliteal vein and other small veins*
    - *The sciatic nerve, Tibial nerve, and Common peroneal*

1.3.5 Ankle disarticulation (Symes)

- **Location:** at the ankle
- **Anatomical changes:**
  - Removal of the ankle joint, the foot, and part of the lower leg
  - The muscles, veins, and nerves are affected:
    - *Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus, Peroneus tertius, Peroneus brevis, and Peroneus longus* – results in significantly reduced mobility
    - *Anterior tibial vein, Posterior tibial vein, and Peroneal vein*
    - *Tibial nerve and Common peroneal nerve*

1.3.6 Mid tarsal (Chopart/ Lisfranc)

- **Location:** mid tarsal
- **Anatomical changes:**
  - Chopart = to keep the heel and ankle joints intact
  - Lisfranc = removes the entire forefoot
  - The foot has seven tarsal bones comprising the ankle joint and five metatarsal bones comprising the mid-foot
  - During the Chopart amputation, muscles, veins, and nerves affected are:
    - *Abductor hallucis, Flexor digitorum brevis, Extensor digitorum brevis, Abductor digiti minimi*
    - *Dorsal and Plantar arch vein*
    - *Branches of Tibial nerve that innervate the muscles in the midfoot such as the Medial plantar nerve, Lateral plantar nerve, Tibial nerve proper*
  - During the Lisfranc amputation, muscles, veins, and nerves affected are:
    - *Tibialis anterior, Peroneus longus and brevis, Extensor hallucis longus*
    - *Dorsal and Plantar arch vein*
    - *Branches of the Tibial nerve that innervate the muscles in the midfoot and the Deep peroneal nerve innervating the dorsum of the foot are affected.*

1.3.7 Digits

- **Location:** interphalangeal or metatarsophalangeal joints
- **Anatomical changes:**
  - Removal of one or more digits can occur at various levels
  - The foot has 14 phalanges that make up the toes
  - The muscles, veins, and nerves affected are:
    - *Intrinsic foot muscles: Abductor hallucis, Flexor digitorum brevis, Flexor hallucis brevis, Lumbricales, Plantar interossei* – located within the foot and control the toes and foot arch movement
    - *Dorsal and plantar venous arch*
    - *Tibial nerve, Peroneal nerve, and the Sural nerve*

1.4 LLA Prosthetics

LLA prosthetics are artificial devices used to replace a (partially) missing lower limb, such as the foot or even the entire leg from the hip down, to achieve similar physiological movement of the missing limb (*Windrich et al., 2016*). An LLA prosthetic typically consists of a socket that fits onto the residual limb. Depending on the level of the amputation and the patient's needs and goals, the prosthetic's design will differ.

1.4.1 Goals

The goal of an LLA prosthetic is to (*Windrich et al., 2016; Kapp et al., 2009*):

1. Improve mobility
2. Improve balance and stability
3. Increase independence

1.4.2 Types of LLA Prosthetics

There are three main types of LLA prosthetics (*Berke et al., 2012; Windrich et al., 2016*; *Kapp et al., 2009*):

1. **Passive prosthetics**
    - It has no active components
    - Provides support, stability, and some degree of mobility
    - Typically, light-weight material and a simple design that does not require additional energy input
    - Suitable for low-activity patients
2. **Dynamic-response prosthetics**
    - Energy storage and return during walking, which helps provide a more natural gait, reducing healthy limb strain and reducing energy expenditure
    - Typically have a spring or hydraulic mechanism that stores energy during the early stance phase and releases it during the late stance phase (mimics ankle joint function)
    - Suitable for patients with moderate activity or require some level of mobility or energy expenditure (e.g., walking on uneven surfaces)
    - The use of sensors and microprocessors helps detect changes in the patient's movements to adjust the prosthetic accordingly
3. **Powered**

- It provides additional energy input to help mimic the physiological movement of a healthy leg and increased energy expenditure
- Either:
    - Battery-powered motor - drives the prosthetic joint, providing propulsion during walking
    - Myoelectric prosthetic - uses electrical signals generated by the muscles in the residual limb
- It provides a greater ROM
- Suitable for patients with high activity levels or required high levels of mobility or energy expenditure (e.g., jumping, running)

Specialized prosthetics

These LLA prosthetics are designed to improve the performance of those with a lost limb, mimicking the biomechanics of physiological limb movement but with enhanced support and stability. For instance (*Bragaru, Dekker and Geertzen, 2012; Owens et al., 2011*):

Running	• Designed to mimic the natural motion of the leg during running • Typically, light-weight material (e.g., carbon fiber) • It provides a spring-like motion to help generate more power with each stride • The length and shape of the prosthetic are essential to ensure proper stride length and foot placement
Swimming	• Designed to improve the propulsion and stability of the swimmer • Typically, silicone or carbon fiber provides maximum buoyancy, reduces drag, and streamlines the body to the position of the swimmer
Cycling	• Designed to mimic the natural motion of the leg during pedaling • Typically, light-weight material (e.g., carbon fiber) • It provides a smooth, efficient pedaling motion

Table 1: Sports and their specialized prosthetics

1.4.3 Biomechanics of LLA prosthetics

The LLA prosthetic works biomechanically to mimic the physiological movements of a leg. They are designed to absorb shock, support the body's weight and facilitate natural gait (*Kapp et al., 2009; Rajťúková et al., 2014)*.

The design and mechanical properties of a prosthetic limb include several components and must be adapted to the needs of individual patients (*Rajťúková et al., 2014)*:

Socket	It fits over the residual limb and is designed to distribute pressure evenly to prevent discomfort and skin breakdown.
Suspension system	It holds the prosthetic in place and is designed to accommodate different types of activity levels (e.g., sports, everyday use)
Prosthetic foot and ankle	It is designed to mimic the function of a natural limb and can be made from a variety of materials (e.g., carbon fiber to give it strength and flexibility) The prosthetic foot needs to have the ability to absorb shock and keep balance on uneven terrain, while the ankle needs to allow for natural rotation (e.g., to help reduce joint pain). Both must provide stability and support during gait.
Control mechanism	It allows the patient to operate the prosthetic limb and can range from a simple switch to more advanced mechanisms such as a myoelectric one.

Table 2: LLA prosthetics components

Factors that affect performance include (*Klut, Kallfelz, and Czerniecki, 2001*):

1. Body weight
2. Activity level
3. Residual limb length
4. Shape
5. Design
6. Material used

For instance, a heavier prosthetic limb may require more energy to move, while a stiffer prosthetic foot may be more durable but less comfortable)

1.4.4 LLA prosthetic fitting and process

Generally, the prosthetic fitting can be done as soon as the stitches are removed, and the residual limb has healed and stabilized in size and shape. However, this can vary depending on overall health, amputation level, and healing process. Generally, the earliest a prosthetic fitting can be done is around four to eight weeks after surgery (*Berke et al., 2012; Kapp et al., 2009; O'Keeffe and Rout, 2019*).

Several steps are involved, including (*Berke et al., 2012; Windrich et al., 2016; O'Keeffe and Rout, 2019*):

1. Initial evaluation and assessment by a prosthetist to assess the patient's needs and goals and determine the type of prosthetic required
2. Casting or scanning of the residual limb to create a custom socket for the prosthetic
3. The making of the prosthetic components
4. Fitting and adjustments of the components
5. Training and rehabilitation to learn how to use the prosthetic, build strength and endurance
6. Continuous follow-up and any adjustments that may be needed

1.4.5 Complications

Complications include (*Berke et al., 2012; Windrich et al., 2016; O'Keeffe and Rout, 2019*):

1. Skin irritation
2. Pressure sores
3. Infections
4. Discomfort

According to Berke et al. (2012), potential changes in their residual limb shape and size can impact the fit and function of the prosthetic over time. Therefore, it must be properly fitted but also regularly checked.

1.4.6 Eligibility

Most patients with hip disarticulation or transfemoral amputations are eligible for a prosthetic. However, it depends on some factors such as those (*Berke et al., 2012; Windrich et al., 2016; Klut, Kallfelz, and Czerniecki, 2001*):

1. Overall health
2. Any co-morbidities
3. The extent of the amputation
4. Healing process
5. Activity level

1.5 Stages of LLA

1.5.1 Pre-operation

The location and level of the amputation are determined by considering the severity of the underlying pathology or condition (*Molina and Faulk, 2021; Murphy, 2014; Nordon, Hinchliffe, and Jones, 2012*). It is essential to consider how long the residual limb length should be for the potential prosthetic to fit well (*Robinson et al., 2010*). Fitting the prosthetic joints (common in trans-femoral amputations) can be challenging if it is too long. A recommended guideline is to amputate approximately in the middle third of the femur for adults. This would provide about 12cm of space above the knee joint. For trans-tibial amputations, a reasonable level is 10cm below the knee joint (*Nordon, Hinchliffe, and Jones, 2012*; *Robinson et al., 2010*).

When assessing the mobility potential of the patient, it is essential to take into account the energy demands that come with each amputation level and, in addition (*Robinson et al., 2010*):

- any pre-existing health issues (e.g., COPD, Parkinson's, DM, LBP)
- muscle activation and control
- endurance and power
- cognitive function
- sensation

The pre-surgery stage involves (*Dillingham, Pezzin, and MacKenzie et al., 2002; MacKenzie et al., 2006; Molina and Faulk., 2021; Esquenazi and Yoo., 2016; Becker et al., 2011*; *Robinson et al., 2010*):

1. **Evaluation and preparation –** anamnesis, medical and physical examination assessing overall health and extent of limb damage to determine the level of amputation
2. **Choosing the appropriate level of amputation –** based on the level of tissue damage, functional needs, health status of the patient, and whether or not an infection is present
3. **Education** of the patient and their family, providing information on the expected outcomes of the procedure, potential risks and complications, and the rehabilitation process

1.5.2 Operation

The surgeon must plan the scar placement on the residual limb as it is essential to avoid areas that may experience high levels of pressure or friction during the prosthetic usage. In addition, proper shaping of the residual limb through timely bandaging will help facilitate easy application and removal of the future prosthesis while offering protection against potential pressure ulcers (*Robinson et al., 2010*).

1.5.2.1 Contraindications

There are several contraindications involved in an LLA:

Elderly patients with co-morbidities	Critically ill states
Low physiologic reserve	Poor healing and recovery
Active infection in the affected limb	Inability to tolerate anesthesia
Poor pain relief or unrealistic expectations about the procedure's results.	Health conditions that could impair the healing process (e.g., uncontrolled DM or CVD)
Psychological or social factors – e.g., severe depression, lack of support system	

Table 3: LLA operation contraindications

(*Molina and Faulk, 2021; Adams and Lakra., 2022*)

1.5.3 Post-operation

Several stages in the post-operative rehabilitation phase have been identified by the American Congress of Rehabilitation Medicine (*ACRM, 2019*):

1. **Acute post-operative phase**
    - 1-7 days post-operation (*Robinson et al., 2010; Esquenazi & Yoo, 2016*)
    - Main goals: reduce pain, PLP, and edema via positioning, emotional support, and proximal body motion *(Dillingham et al., 2002; MacKenzie et al., 2006; ACRM, 2019; Robinson et al., 2010; Esquenazi & Yoo, 2016)*
2. **Pre-prosthetic phase**
    - Seven days – 6/8 weeks (*Robinson et al., 2010*)
    - Continues work of the first phase and focuses on strengthening, flexibility, final shaping of the residual limb, and re-education of gait *(Dillingham et al., 2002; MacKenzie et al., 2006; ACRM, 2019; Robinson et al., 2010)*
3. **Prosthetic prescription phase**
    - Around 6/8 weeks, there is an assessment conducted by the prothesist, by measuring and casting the residual limb and fitting the primary prosthesis *(Dillingham et al., 2002; MacKenzie et al., 2006; ACRM, 2019; Robinson et al., 2010)*
    - There is the first prosthetic fitting at the 8-10 weeks mark. The initial prosthetic needs to consider the energy cost of the prosthetic gait and potential respiratory or cardiovascular issues LLA patients may face. Therefore, the prosthetic will be as light-weight as possible while maintaining adequate functionality (*Robinson et al., 2010*).

4. **Prosthetic training phase**
    - 10 weeks + (*Robinson et al., 2010*).
    - The main goals are to manage weight-bearing and ADLs, re-educate muscle control, and train gait, balance, and proprioception, in order for the patient to become independent and safe *(Dillingham et al., 2002; MacKenzie et al., 2006; ACRM, 2019; Robinson et al., 2010)*

5. **Reintegration phase**
    - The main aim is to regain the ability to perform specific activities; thus, the rehabilitation process is customized to meet each patient's needs and goals moving forward *(Dillingham et al., 2002; MacKenzie et al., 2006; ACRM, 2019; Robinson et al., 2010)*

6. **Maintenance phase**
    - After 1-2 years, there is a reassessment and adjustment if needed *(ACRM, 2019)*

1.5.4 Prosthetic

Using prosthetics can significantly improve the quality of life for individuals who have undergone a LLA, allowing them to continue performing ADLs. However, the most crucial factor in determining the success of a prosthetic device is the fit and alignment with the residual limb (*O'Keeffe and Rout, 2019*). As stated before, poor-fitting or misaligned prosthetics can cause discomfort and pain and promote bad habits and musculoskeletal changes leading to conditions such as LBP (*Berke et al., 2010*).

1.6 Prognosis

Patients who have undergone successful surgeries generally experience good recovery and adapt well to their new situation. However, research by Marshal and Stansby (2008) suggests that in the UK, approximately 50% of patients who have undergone lower limb amputation due to ischemia will require amputation of their other limb within two years. Additionally, patients who experience poor blood perfusion after amputation have a life expectancy of only 31% after five years, and they may also have to deal with other significant health concerns.

1.7 Complications

There is high perioperative mortality after an LLA. Within the first 30 days, this rate can range between 4 to 22%, and in diabetic patients, the mortality rate can be as high as 77% in five years (*Molina and Faulk,2021*).

Many factors can affect how well a wound will heal. These include (*Ashraff et al., 2018; Harker., 2006; AlQaseer, Ismaeel, and Badr., 2017*):

- Patients' age
- Patients' nutrition
- If the patient is a smoker
- Any other pre-existing health issues
- Location of the wound
- Perfusion level to the area
- How well the surgery was done

How well the wound heals is essential because it determines if a person can use a prosthetic limb. However, it is not uncommon for there to be wound-healing complications post-surgery (*Harker, 2006*)

Some complications:

1. **Wound infection**
    - Infections can lead to further complications such as wound dehiscence (*Baxter, 2003*), tissue necrosis, or cellulitis – an inflammation with pus and possibly accompanied fever leading to sepsis (*Harker, 2006*)
    - Diabetic patients are 5x more prone to infections post amputation and may need a re-amputation compared to non-diabetic patients (*Ashraff et al., 2018; de Godoy et al., 2010; AlQaseer et al., 2017*)
    - To reduce cellulitis the sepsis risk, antibiotics are used (*Harker, 2006; de Godoy et al., 2010*)

2. **Tissue necrosis**
    - Occurs due to poor tissue perfusion and circulation into the stump (*Ashraff et al., 2018; AlQaseer et al., 2017*):
        - Skin color changes
        - Wet or dry gangrene
    - Removing tissue necrosis or debridement occurs naturally through autolysis if a smaller surface area is affected or by surgery. If a larger surface area is affected, Necrotic tissue is removed to accelerate the healing process (*Harker, 2006*). Larval therapy, which requires no anesthetic, can also be used and is common practice in the UK (*Fan et al., 2020*).

3. **Pain (***Harker., 2006***)**
    - Different types of pain can affect the healing process and quality of life:
        a) Stump pain from the surgery wound. This pain is local and felt as ‘’throbbing’’ or ‘’burning’’ pain by patients (*Harker, 2006; Marshal and Stansby, 2008)*
        b) PLP is commonly felt by up to 80% of patients post-amputation. The pain can be intermittent or permanent, ranging from a few seconds to a few hours. The intensity, duration, and frequency of pain usually reduces within the first six months, but with some, it may last for years to come (*Harker, 2006; Erlenwein et al., 2021; AlQaseer et al., 2017*)
        c) Infection
        d) Pressure pain from a prosthesis
        e) Tissue necrosis

4. **Wound breakdown**
    - Also known as dehiscence is when the wound opens or does not heal properly, and the bone and muscles are exposed (*Baxter, 2003*). Factors include infection, straining the wound, too much movement or too large ROM, poor healing, trauma when the wound is not strong enough to handle the forces acting upon it, swelling causing tension, or even early suture removal (*Harker, 2006*).

5. **Problems associated with the surrounding skin**
    - Problems include (*Harker, 2006*):
        - Blisters – can occur with constant skin friction, traction, edema (and bandaging being inelastic enough), or infection
        - Dehiscence cause the wound to be sensitive and painful, slowing down the healing
        - Ulcers – often result from Impaired sensation due to friction or even pressure from prosthetic

6. **Bone erosion**
    - The bone may protrude, and muscle retraction may occur on the stump. It can lead to sepsis if untreated. Thus, surgery is required if the exposure area is too large for the healing process. Granulation cannot cover it (*Marshal and Stansby, 2008; Ashraff et al., 2018*).

7. **Hematoma**
    - Built-up blood in a tissue or space can lead to infection and create an area of dead tissue. This can weaken the area where the wound was closed, increasing tension (*Marshal and Stansby, 2008; Baxter, 2003*; Harker, 2006).
    - Surgery is necessary if a hematoma covers a large surface area and has clots. However, more minor hematomas may drain on their own (*Harker, 2006*)
    - Hematomas affected 12-34% of trans-tibial amputees and 6-16% of trans-femoral amputees (*Molina and Faulk, 2021*)

8. Stump edema

- Edema delays healing. It can occur due to deep vein thrombosis, fluid retention, or chronic hypervascularity (*Ashraff et al., 2018; Marshal and Stansby, 2008*).
- Proper skin hygiene is essential to preventing infections like cellulitis as it maintains normal lymphatic and cellular function, whereas poor hygiene can impair these functions (*Casey, 2004*).
- Elevation of the stump can help reduce edema, and wrapping the stump with an elastic bandage can limit inflammation and maintain the shape of the stump. This is vital for using a prosthetic limb in the future. (*Ashraff et al., 2018; Harker, 2006*)

1.8 Patho-kinesiology of LLA

Degenerative changes and pathologies in the musculoskeletal system can occur due to lower limb amputation. These issues arise from secondary conditions that stem primarily from increased loading on the healthy limb and insufficient loading of the residual limb, leading to Osteoarthritis (OA) in the hip and knee joints of the healthy limb and osteopenia or osteoporosis in the residual limb. This loading imbalance disrupts body mechanics, which can be attributed to the amputation of the lower limb or the use of a prosthesis (*Gailey et al., 2008*).

Muscle atrophy

The loss of a major limb is a significant life change that requires individuals to develop new ways to move with or without a prosthetic. However, this adaptation process may lead to muscle imbalances, where some muscles weaken from underuse while others strengthen from overuse to compensate (*Henderson et al., 2021*). Prolonged asymmetrical loading can exacerbate this issue, causing atrophy - in which the muscle fiber size and strength are reduced, especially in the residual limb. This can harm functional ability and gait, resulting in difficulties with balance and mobility (*Rutkowska-Kucharska, Kowal, and Winiarski., 2018*).

Muscle atrophy can occur for several reasons:

1. Under- or dis-use
    - Due to lower physical activity in the residual limb, muscles are not stimulated enough (*Phillips, Glover, and Rennie., 2009*)
2. Reduction in nerve stimulation
    - Also known as neurogenic atrophy. After an LLA, nerves connecting to the muscles may be affected/ damaged and, thus, cannot stimulate the muscle to contract, leading to lowered activity of the muscle (*Dhillion et al., 2004*)
3. Changes in hormones
    - It is common for LLA patients to have altered hormonal levels, for instance, increased cortisol levels which, if persistent along with long-term inactivity, can act as a catabolic stimulus that contributes to reduced muscle protein synthesis leading to muscle atrophy (*Paddon-Jones et al., 2006*)

Muscles that tend to weaken after an LAA are:

1. **Quadriceps femoris** – overall, shows the most significant atrophy. The rectus femoris loses function of quadriceps EXT, the vastus medialis, and lateralis (*Dong, Bai, and Liu, 2021; Fontes et al., 2021*)
2. **Gluteus maximus** (*Henson et al., 2021)*
3. **Abdominals –** due to reduced core stability (*Dong, Bai, and Liu, 2021)*
4. **Hamstrings –** significantly reduced due to disuse and reduced physical activity when no prosthetic is used (*Henson et al., 2021)*

Muscles that tend to strengthen after an LAA are:

1. **Hamstrings –** compensating for the quadriceps femoris and triceps surae in propulsion during gait with a prosthetic and encourages weight bearing on the residual limb (*Dong, Bai, and Liu, 2021*)
2. **Triceps surae** – on the healthy limb, to aid in maintaining balance and stability (*Henson et al., 2021)*
3. **Back muscles –** primarily the Erector spinae and Latissimus dorsi compensate for reduced core stability (*Friel, Domholt, and Smith., 2005)*

According to a study by Dong, Bai, and Liu (2021), the biceps femoris long head, semimembranosus, and gracilis show the lowest muscle atrophy. After an LLA, posture during stance and gait has the tendency to be asymmetrical, and often there is a deviation in hip position and forward weight shifting, causing hamstrings to contract to provide waist and residual leg support to keep the trunk upright during sitting and maintain overall body balance as a compensatory mechanism instead of the quadriceps, adductors, and gluteus maximus which would be active in stance and the lost foot and knee strength and function. (*Rutkowska-Kucharska, Kowal and Winiarski., 2018; Dong, Bai and Liu., 2021; Berke et al., 2012)*

Dong, Bai, and Liu (2021) observed that patients with a prosthesis exhibited less discrepancy in their muscle area ratio between their limbs than those without a prosthesis. This could be attributed to the prosthesis aiding in compensating residual limb function, ultimately resulting in improved physiological and gait adjustments. Additionally, the muscles near the hip joint, such as the biceps femoris and adductors, exhibited better function and less atrophy due to their attachments, in contrast to muscles closer to the end of the residual limb.

Joint mechanical changes

As a result of increased joint stress and weight-bearing, mechanical modifications in the joints arise, resulting in joint degeneration and pain. If exposed to high repetitive loading forces over an extended period, weight-bearing joints degenerate and subsequently induce joint pain (*Zhang and Jordan., 2010*).

These changes often result in Osteoarthritis and bone loss:

1. Osteoarthritis

Patients that have undergone an LLA show an increase in the chance of developing Osteoarthritis (OA), especially patellofemoral OA, in the healthy knee compared to the residual limb compared to individuals without amputation (*Gailey et al., 2008; Welke et al., 2019*). This is because joints with OA cannot absorb forces efficiently, leading to the forces being re-transmitted to the cartilage (*Gailey et al., 2008*). In addition, those with amputation tend to compensate for the lost limb by increasing the load on the healthy limb, particularly during gait, due to asymmetrical ambulation, in patients with and without (long-term) prosthesis. This increases hip and knee OA incidence from increased mechanical stress (*Norvell et al., 2005; Gailey et al., 2008*).

A study by Struyf et al. (2009) found an increase in hip and knee OA of 14% and 27%, respectively, while Norvell et al. (2005) amputees examined showed a 16.1% increase in OA versus 11.7% for non-amputees. Although many factors influence the degree of OA and prevalence within those with an LAA, to check that the condition is not more common in those with higher general de-conditioning or greater body weight, Norvell et al. (2005) conducted a study controlling body weight, and concluded that transtibial and transfemoral amputations were 3x and 5x respectively, more likely to have knee pain in the healthy limb versus the controls.

2. Osteoporosis and bone loss

Bone loss in the residual limb occurs due to prolonged disuse and altered weight bearing. This increases fracture risk. (*Haleem et al., 2011*). According to Gailey et al. (2008), LLA patients are at a greater risk of osteoporosis in their residual limb femur due to several factors. These factors include the effects of disuse atrophy and immobilization of the residual limb within the prosthesis socket. Furthermore, reduced muscle contraction and decreased vertical loading on the residual limb may also contribute to the increased risk.

Phantom limb pain (PLP)

PLP is a common complication in LLA patients. It is a chronic and intermittent pain or discomfort perceived in the missing limb. This pain can manifest in various forms, such as pins and needles, burning, stabbing, or throbbing (*Hanyu-Deutmeyer, Cascella, and Varacallo., 2021*). MacLachlan and Hallam (2011) state that early prosthetic use and pre-operative psychological preparation can help manage PLP.

Back pain

A 52 to 72% prevalence of lower back pain (LBP) was present in LLA (*Hammarlund et al., 2011; Shojaei et al., 2016*). Asymmetrical stance and gait due to force distribution being dominant on the healthy limb and the increased lumbar lordosis due to increased anterior pelvic tilt commonly lead to LBP (*Gailey et al., 2008*). According to Ehde et al. (2000), a significant proportion of LLA patients (52%) reported experiencing constant LBP, with 17% describing it as their most severe pain. Similarly, Kulkarni et al. (2005) found that 63% of their sample reported moderate to severe levels of LBP, with 60% of cases developing within two years of amputation. Furthermore, 38% of the participants reported that their LBP significantly interfered with their daily activities. Also, improper prosthetic fit in individuals with amputation can result in a discrepancy in leg length, which can lead to back pain (*Gailey et al., 2008*)

Gait pattern alteration

LLA patients tend to adopt a specific posture, during both stance and gait, that involves spending more time on their intact limb versus the residual limb or prosthetic limb, potentially to enhance medial/lateral stability and as a protective mechanism post-surgery to protect the soft tissues in the residual limb which cannot be loaded, but also increasing the weight bearing on the intact limb (*Boonstra et al., 2013*).

The weight bearing should be equally distributed between the legs when standing. However, those with an LLA continue to load the healthy limb more than the prosthetic one and tend to have more significant sway. According to Gailey et al. (2008), this increased sway is likely due to the absence of proprioception in the prosthetic leg.

An altered gait pattern is adopted after an LLA, with or without a prosthesis, as losing a limb changes the COG and affects balance and stability (*Boonstra et al., 2013*). Gait asymmetry occurs due to several factors, such as long-term uneven loading and muscle atrophy, but also factors such as age, general conditioning, type of prosthetic if applicable, etc. (*Rutkowska-Kucharska, Kowal and Winiarski., 2018*).

After an LLA surgery, the initial compensation during gait ADD the healthy limb towards the midline and slightly increasing EXT ROT to help manage their balance and stability. This increases joint forces in the healthy limb and decreases joint forces on the residual limb during walking at a comfortable pace the individual (*Rutkowska-Kucharska, Kowal, and Winiarski., 2018)*.

The limited ROM also influences transfemoral amputees' gait in their residual limb's hip EXT, likely due to the tendency of the iliopsoas muscle shortening. Due to this shortening, it may cause difficulty in swing phase initiation during gait, cause hip hiking or pelvic rotation (*Gailey et al., 2008*)

LLA patients experience more significant spinal loading during gait, mainly due to the complex recruitment of trunk muscles, particularly the antagonistic co-activation during the limb stance phase. As a result of increased trunk motion, the trunk muscles respond more intensely to maintain spinal stability, which may increase loading and the risk of lower back pain due to the repetitive gait cycle (*Adams et al., 2007; Shojaei et al., 2016*). The highest muscle force and spinal loading occur during the heel strike and toe-off phases of the gait cycle, characterized by substantial axial trunk twisting and asymmetrical trunk posture, according to Hendershot and Wolf (2014).

A study comparing ground reaction forces (GRFs) has revealed that individuals with unilateral LLA experience up to 23% force asymmetry depending on the type of prosthesis, whereas non-amputees exhibit less than 10% force asymmetry. Furthermore, the resulting adaptations in the intact limb increase the net joint moments and power output, which has implications for the hip, knee, and ankle joints (*Nolan et al., 2003*).

Nervous system changes

Changes in the nervous system (NS) post-surgery, such as damage, can affect sensory and motor function (*Tominaga and Matsuo, 2016*).

- Sensory function – altered sensation and touch sensitivity, PLP
- Motor function – reduction in muscle contraction due to poor connection, leading to decreased muscle strength and coordination

Importance of suitable fitting prosthetic

Several factors must be considered deciding to use a prosthetic, including proper socket fitting, appropriate alignment of the prosthetic with the residual limb, and ensuring that the total length of the prosthetic matches the healthy limb. These measures help maintain continuous biomechanics, prevent leg length discrepancy, and facilitate equal force distribution between the healthy and the prosthetic limbs during stance and gait *(Gailey et al., 2008*; (*Sin, Chow, and Cheng., 2001*).

Gailey et al. (2008) found that well-fitted prosthetics for transtibial amputees did not cause significantly greater forces on the joints of the opposite limb than non-amputees. Unequal force distribution over time commonly results in secondary complications such as increased OA, LBP, muscle atrophy risk, poor posture and gait, and discomfort and pain (*Sin, Chow, and Cheng., 2001*).

Using a prosthesis for at least 7 hours/ day is common among 68-88% of LLA to improve their mobility and ADLs ability. However, most of those exhibit at least one gait deviation, which can be attributed to incorrect prosthetic fit or alignment, insufficient gait training, development of poor habits, or compensating for secondary physical limitations *(Gailey et al., 2008*). Out of 78 traumatic LLA patients conducted in a study by Dillingham et al. (2001), only 43% were satisfied with their prosthesis, and 23% reported skin irritation and wounds.

2 Physiotherapy and Rehabilitation in LLA

2.1 Physiotherapy goals

Rehabilitation post-LLA is a long-term process that includes various life aspects which must be taken care of to have a good outcome. Therefore, the specific goals for each phase may vary based on individual patient needs and the amputation level.

2.1.1 Pre-operation

Short term:

1. Patient education about the amputation process and what to expect post-operation in order to prepare the patient for the post-operation rehabilitation process
2. To help manage the patient's pain and discomfort

Long term:

1. Improving the patient's overall physical health and fitness to help them manage the physical demands after the surgery

2.1.2 Post-operation

Short term:

1. Pain management and reduction of post-operative edema
2. Restoration of mobility and independence (e.g., performing ADLs, use of assistive devices, transfers, and even gait training)
3. Strengthening the residual limb and surrounding muscles
4. Improving balance and coordination
5. Preventing secondary complications (e.g., contractures, PLP)
6. Educating the patient about proper wound care

Long term:

1. Promoting the patient's overall physical fitness and helping them regain strength and function; improving patient balance and coordination
2. Continued restoration of mobility and independence, including using transportation and returning to work and hobbies, with or without a prosthetic
3. Continued strengthening of the residual limb and surrounding muscles
4. Continued improvement in balance and coordination

2.1.3 Prosthetic

Short term:

1. Ensuring the patient's prosthetic device is fitted correctly and aligned
2. Teaching the patient how to use and care for their prosthetic

Long term:

1. Helping the patient to adapt to using their prosthetic in their daily life
2. Improving balance and gait with the prosthetic
3. Continuing to promote overall physical fitness and health

(*Stanford Health Care., n.d.; MacKenzie et al., 2006; Dillingham, Pezzin and MacKenzie., 2002*)

2.1.4 Challenges

The rehabilitation process is complex, and achieving goals can be challenging for numerous reasons:

- Complications with healing
- Overall poor conditioning or the health of the remaining limb (e.g., poor blood flow, pain, sensitivity)
- Other pre-existing health issues or pathologies hindering progress (e.g., problems with balance, reduced muscle strength)
- The psychological impact (e.g., emotional, demotivated, depression)
- Obstacles such as not having support, living alone, inaccessible professional help and aids, ill-fitting walking aids

(*Stanford Health Care., n.d.; Gailey et al., 2008; Berke et al., 2012*)

2.2 How to reach rehabilitation goals

Muscle strengthening lower body:

- Muscles that tend to weaken after an LLA:
  - *Quadriceps femoris, Hip flexors, Gluteal muscles*
- They weaken due to compensatory changes in gait patterns, shifted weight distribution, and muscle disuse
- Resistance exercises (e.g., with body weight, weights, or Therabands)**,** Stair climbing or step-ups

Muscle strengthening upper body:

- Muscles that tend to weaken after an LLA:
  - *Shoulder stabilizers, Rotator cuff, Back muscles*
- They weaken due to gait pattern changes and shifted weight distribution, increasing stress on the shoulder and back muscles, leading to fatigue. The use of crutches for prosthetics can place further strain on these muscles.
  - For instance, when using crutches, the individual will tend to lean forward, shifting their weight onto their arms and increasing stress on the shoulder stabilizers and rotator cuff.
- Resistance exercises (e.g., with body weight, weights, or Therabands)

Muscle stretching lower body:

- Muscles that tend to shorten after an LLA:
  - *Hamstrings, Triceps surae, Hip flexors*
- They shorten due to changes in gait patterns and shifted weight distribution, increasing stress on the healthy limb and causing overuse of these muscles in order to maintain balance and stability.
  - For instance, after an LLA, one tends to adopt a more flexed hip position in stance and during gait, leading to hip flexor shortening.

Muscle stretching upper body:

- Muscles that tend to shorten after an LLA:
  - *Chest, Shoulders, Upper back*
- They shorten due to changes in posture and compensatory movements
  - For instance, the pectoral muscles tend to shorten due to increased forward leaning of the upper body, which is done to maintain balance. In addition, the upper trapezius and levator scapulae shorten due to increased usage during ADLs, such as reaching or lifting objects. This causes rounding of shoulders and neck pain.

Training balance and stability:

- Proprioception exercises such as the single leg stance, weight shifting, or balance drills on a foam
- Strength training to build strength in the core, hips, and healthy limbs can help improve balance
- Gait and mobility training to re-educate how to walk and move around
- Use of assistive devices

Training CV fitness:

- Aerobic exercise, low-impact activities such as cycling
- Resistance training

2.3 Current treatment approaches

There have been several therapeutic approaches and procedures developed for lower limb amputation patients that are supported by high-level evidence-based medicine (EBM) studies such as:

1. **Mirror Therapy**
    - Mirror therapy involves using a mirror to create the illusion of a functional limb in place of the amputated limb, which can help effectively reduce PLP and improve functional outcomes compared to standard care.
    - Studies according to Herrador Colmenero et al. (2018) and Campo-Prieto and Rodriguez-Fuentes (2022), found that mirror therapy was effective in reducing PLP, its intensity, and even the duration of pain during episodes.

2. **Neuromuscular electrical stimulation (NMES)**
    - NMES is a therapeutic technique that involves using electrical currents to stimulate nerves and muscles
    - According to a systematic review and meta-analysis by Abou et al. (2022), it can be used in combination with exercise or gait training to improve motor function, muscle strength and gait speed.

3. **Hydrotherapy**
    - It is a low-impact activity and reduces stress on the healthy limb as the water provides buoyancy and support and helps improve mobility, reduce pain, and increase strength (*Egan and Fitzpatrick, 2017*)

4. **Psychological interventions**
    - As previously mentioned, LLA surgery can impact a person's mental health significantly.
    - Cognitive Behavior Therapy (CBT) is an effective intervention to improve mental health, reducing depression and anxiety in LLA patients (*Alavi, Molavi, and Molavi, 2017; Mayo et al., 2022*)

5. **Prosthetic fitting and training**

- As previously mentioned, it is an essential component of rehabilitation for some patients as it helps restore mobility, function and independence (*Berke et al., 2010)*
- Proper fitting and training can help prevent secondary health issues through proper gait mechanics, as LLA patients have an increased risk for LBP and joint pain due to altered gait biomechanics.
- Prosthetic training programs that involved regular visits with a prosthetist and individualized training sessions were associated with better prosthetic use and patient satisfaction (*O'Keeffe and Rout, 2019*)

6. **Telehealth intervention**

- Telehealth intervention for LLA patients is when technology is used to deliver healthcare services remotely (e.g., via video consultations, mobile app, or using wearable devices to track progress and monitor health status)
- This has improved access to post-surgery care and allowed for more frequent and regular checkups, allowing for supervised and monitored exercises and education, which can lead to better outcomes (*Imam et al., 2014*)

7. **Osseointegrated implants**

- Involve surgically attaching a prosthetic limb directly to the bone rather than using a socket. This provides a stable and secure attachment point for the prosthesis.
- A study by Hoyt, Walsh, and Forsberg (2020) found that osseointegrated implants were associated with better prosthetic use (including greater mobility and control), lowered risk of skin breakdown and discomfort, and higher patient satisfaction compared to traditional socket prostheses.

3. Special part – Case Study

3.1 Methodology of work

Diagnosis

- **17.11.2022:** acute hospitalization for pain in left lower extremity periphery. Arteriosclerosis of peripheral arteries without gangrene.
- **05.01.2023:** Transfemoral amputation of left lower limb

Aims: The main goal is to return the patient to independence with or without a prosthesis. This is done by strengthening muscles in the upper body and remaining limb, lengthening shortened muscles, training transfers, and wheelchair and crutches training. The case study was conducted in Nemocince na Homolce between 09.01.2023 – 27.01.2023. There were 16 therapy units which ranged between 45 – 70 min.

Examinations used	
Observation	Neurological – sensations
Breathing pattern	Fascia
Muscle strength tests	Posture
Anthropometric measurements	Movement pattern
Goniometry and ROM	Gait assessment and assistive aid use
Muscle tone	

Table 4: Examinations used

Therapeutic methods used	**Therapy aids used**
Strengthening	Two waterbottles
Stretching, MET techniques	Theraband
Respiratory physiotherapy	Wheelchair
Transfers and mobility	High walker
Myofascial release	Crutches

Table 5: Therapeutic methods and Therapy aids used

3.2 Initial kinesiological examination

3.2.1 Status praesens

Data were taken on the day of hospitalization, 17.11.2022

Name: B. J.

DOB: 07.02.1954

Weight	79kg	**Dominant limb**	Right-handed
Height	173cm	**Breathing frequency**	16 min^{-1}
BMI	26.4	**Saturation**	98%
Sex	M	**Blood pressure**	140/90 mmHg

Table 6: Basic patient information

Objective: eupnea, orientated, communicative, neurologically in the norm, wears glasses.
Subjective: pain in lower left extremity periphery, has felt intermittent pain since afternoon (15.11.2022)

3.2.2 Anamnesis

Personal:

- Hypertension – treated
- Increased glycemia, pre-diabetes
- 2012 iliofemoral bypass l.dx. at IKEM
- 2013 femoropopliteal proximal bypass l.sin. at IKEM
- 2015 microsurgery sequestromy of L4/5 l.dx.
- 09.09.2020 femoro-poplitealis proximalis protheticus novus l.sin.
- 06/2022 Resectio partis proximal bypass femoro-poplitealis l.sin.
- 11/2022 lovectomia sup. Pulm l.dx., lymfadenectomia

Family:

- Father, diabetic, passed away due to old age at 90
- Mother passed away due to old age at 92
- Has two healthy children

Social: Married, lives with wife

Medical:

- Fraxiparine 0,3 ml s.c. 1x/ day
- Cosyrel 10 mg/ 5mg tbl p.o. 1-0-0
- Mertenil 20mg tbl p.o. 1-0-0
- Milurit 100mg tbl p.o. 0-1-0

Occupational: Retired, used to be a locksmith

Hobbies: Likes to build usable cars from scrap

Abuses: Ex-smoker since March 2020, prior smoked 10-20 cigarettes/ day

Allergies: Yes – not given

Diet: Diabetic

3.2.3 Additional data – First therapy unit

This data was taken additionally in the first therapy unit: 06.01.2023

Weight - day of amputation (05.01.2023): 70kg

Stump description: The stump is bandaged and has stitches to close the incision. The shape is irregular due to swelling and edema

Breathing Pattern: In supine-dominant abdominal breathing, no accessory muscles are used, and the chest is symmetrical

Muscle strength (grading of 0-5, according to Janda):

	Right limb	**Left limb**
Hip FLX	Grade 5	Contraction seen but painful
Hip ABD	Grade 5	Contraction seen but painful
Knee FLX	X	X
Knee EXT	Grade 5	X
Ankle dorsiFLX	Grade 5	X
Ankle plantarFLX	Grade 5	X
Ankle Inversion	Grade 5	X
Ankle eversion	Grade 5	X

Table 7: Initial kinesiological examination - Muscle strength tests

Anthropometrics

	Right limb (cm)	Left limb (cm)
Anatomical length	88	X
Functional length	91	X
Thigh + 10cm > knee circumference	37	X
Thigh + 15cm > knee circumference	40	X
Stump thigh circumference	X	45.5
Thigh length	44	X
Stump length	X	32
Knee circumference	35.5	X
Calf circumference	29.8	X

Table 8: Initial kinesiological examination - Anthropometric measurements

AROM goniometry:

Joint	Plane	Left (º)	Right (º)
Hip	S	X – 10 – 25	X – 0 – 90
	F	X – 0 – X	X – 0 – 35
	R	X	30 – 0 – 40
Knee	S	X	0 – 0 – X
Ankle	S	X	25 – 0 – 45
	T	X	20* – 0 – 35*
Shoulder	S	X – 0 – 165	X – 0 – 170
	F	X – 0 – 90	X – 0 – 90
	R	60 – 0 - 45	60 – 0 – 50
Elbow	S	0 – 0 – 140	0 – 0 – 145
	T	80 – 0 – 80	80 – 0 -80
Wrist	S	70 – 0 – 75	70 – 0 – 65

Table 9: Initial kinesiological examination - AROM goniometry measurements. The * was an estimate.

Muscle tone palpation:

Muscle	Left	Right
Rectus femoris	Hypotonic	Hypotonic
Vastus lateralis	Hypotonic	Hypotonic
Vastus medialis	Hypotonic	Hypotonic
TFL	Hypotonic	Hypertonic
Adductors	Hypotonic	Hypertonic
Biceps brachii	Norm	Norm
Triceps brachii	Norm	Norm
Deltoid	Hypotonic	Hypotonic
Pectoralis minor	Hypertonic	Hypertonic
Pectoralis major	Hypertonic	Hypertonic
SCM	Hypertonic	Hypertonic

Table 10: Initial kinesiologic examination - Muscle tone palpation

Neurological examination

After a LLA, it is important to evaluate the patient's sensation.

Sensation sense	• Left and right upper extremities are not affected • The right lower extremity is not affected • Left lower extremity: ▪ Feels the touch but is significantly lessened compared to the right side ▪ PLP intensity varies from mild discomfort to short moments of more severe pain. Felt more like burning and tingling pain with durations generally lasting minutes to an hour. The frequency occurs several times a day.
Joint position and kinesthetic sense	• Left and right upper extremities no affected • Right lower extremity not affected • The left extremity cannot be tested

Table 11: Initial kinesiological examination – Neurological – sensations

Fascia

	Left	Right
Fascia lata and ITB	Restricted	Restricted
Adductors	Restricted	Restricted
Quadriceps femoris	Restricted	Yielding
Pectorals	Restricted	Restricted
Arms	Yielding	Yielding

Table 12: Initial kinesiological examination - Fascia

3.2.4 Additional data – second therapy unit

This data was taken additionally in the second therapy unit: 09.01.2023

Posture examination:

In both sitting and supine positions, the shoulders are elevated, the head protrudes significantly forward, and the patient has a kyphotic back. The patient appears to have upper crossed syndrome (according to Janda), in which the deep neck flexors and both the lower trapezius and serratus anterior would be weakened, and the upper trapezius, levator scapulae, and pectoral muscles tightened.

Breathing pattern

- **Sit:** abdominal breathing dominant, no accessory muscles used
- **Stand:** abdominal breathing dominant, accessory muscles slightly used

Muscle tone palpation:

Muscle	Left	Right
Levator scapulae	Hypertonic – trigger point at the insertion on the superior angle of the scapula	Hypertonic
Upper Trapezius	Hypertonic – trigger point on the posterior border, about 2cm from the base of the neck, and another midpoint about 3cm from the spine	Hypertonic – two trigger points next to each other, about midway between the neck and shoulder
Middle and Lower Trapezius	Hypotonic	Hypotonic

Table 13: Additional Data Second therapy unit - Muscle tone palpation

3.2.5 Additional data – third therapy unit

This data was taken additionally in the third therapy unit: 10.01.2023

Muscle tone palpation:

Muscle	Left	Right
Gluteus medius	Hypotonic	Hypotonic
Gluteus minimus	Hypotonic	Hypotonic

Table 14: Additional Data Third therapy unit - Muscle tone palpation

Movement pattern:

1. **Hip ABD** was conducted only on the side lying on the right side – no hip hiking or EXT ROT is visible. However, hip FLX suggests tight psoas and perhaps weaker gluteus medius. The ROM is restricted.

2. **Shoulder ABD** was conducted. There is shoulder elevation bilaterally at approximately 50^{o} due to overactive upper trapezius and levator scapulae. The patient has a forward head and protracted shoulders. Below the right scapula is a 10cm scar from a lung surgery where one lobe has been removed.

Gait examination in high walker:

The distance covered was approximately 4m. The patients' steps had a smaller stride length; however, they were not hops or jumps but attempts of an actual step. The left hip is in approximately 15^{o} FLX

Additional AROM goniometry data of missing movements:

Joint	Plane	Left (°)	Right (°)
Hip	S F	10 – 15 – 85 10 – 0 – 20	**15** – 0 – 105 **20** – 0 – 35 With pain and weakness in both
Knee	S	X	0 – 0 – **110**
Shoulder	S	**30** – 0 – 165	**30** – 0 – 170

Table 15: Additional AROM goniometry measurements

3.2.6 Additional data – fourth therapy unit

This data was taken additionally in the fourth therapy unit: 11.01.2023

Muscle tone palpation:

Muscle	Left	Right
Paravertebrals	Hypertonic – trigger point found approximately 1.5cm to the midline at level L3-L4	Hypertonic
Biceps femoris	Hypotonic	Hypertonic
Semitendinosus and semi membranous	Hypotonic	Hypertonic
Gluteus maximus	Hypotonic	Hypotonic
Triceps surae	X	Hypertonic

Table 16: Additional data Fourth therapy unit - Muscle tone palpation

Movement pattern:

1. **Hip EXT** was performed bilaterally. The ipsilateral synergistic erector spinae contracts earlier than the primary mover - gluteus maximus to initiate hip EXT, altering the movement pattern on both the left and right sides. Hip EXT ROM is restricted on the left side (measured 10^{o} on day 5), possibly due to the tight psoas. In addition, due to the erector spinae initiating the movement, there can be stress on the lumbar spine, resulting in pain.

Fascia

	Left	Right
Hamstrings	Yielding	Yielding
Lumbar area	Restricted – slight discomfort	Restricted
Thoracolumbar area	Restricted	Restricted

Table 17: Additional data Fourth therapy unit - Fascia

3.2.7 Additional data – fifth therapy unit

This data was taken additionally in the fifth therapy unit: 12.01.2023

Gait examination in crutches:

He was using crutches for the first time. The patient's upper body strength is an advantage, and with the supervision of two physiotherapists holding under his armpit for support, he walked about 4m. The patient was relatively stable and upright. The head protrusion is still significant. His left limb stump tendency to be in about 15º FLX, and his right limb knee FLX is good in the initial swing phase. The patient must focus on placing the end of the crutches in the same line and wide enough to fit his step in.

Note:

The data collected in therapy units four, five, six, and seven, concerning the initial kinesiological examination, were taken at later dates due to physically not being able to in the first therapy unit, one-day post-surgery (e.g., pain, edema)

AROM goniometry results were taken for the initial kinesiological evaluation as it shows the patient's ability to perform functional activities, is a measure of muscle strength, and can help identify areas of weakness when the patient is still in pain from the surgery.

No other therapies, such as ergonomics or electrical stimulation, were used during the four weeks of working with the patient.

3.2.8 Exam conclusion

The initial kinesiological examination post-surgery was limited in data primarily due to pain, limiting the movements to be tested. The right lower extremity graded 5 on strength for all movements examined, with no pain. The left quadriceps femoris showed only a contraction but was painful to move. All movements for the goniometry examination were AROM. No measurements were taken in a prone position. These include hip EXT bilaterally, left hip ABD, hip ADD bilaterally as the left limb could not be ABD for the exam, and shoulder EXT bilaterally. The limb's left hip flexion start position could be seen in approximately 10º FLX, and the ROM is limited due to pain. The right hip flexion is limited. According to Janda, the optimal ROM would be 120/135º FLX. The * at right ankle EV and INV was an estimate.

Missing movement AROM data was taken on 10.01.2023: Right hip EXT and ABD measured at 15º and 20º, respectively, with EXT falling within the norm of 10-30º and ABD being limited by 10º, with the norm being 30-50º (both ranges according to Janda). According to Janda, the right knee FLX is also limited with 110º ROM instead of the norm of 125-160º. Finally, the shoulder EXT was measured bilaterally with results of 30º, falling on the lower end range of the norm.

The stump is bandaged and has stitches to close the incision. The shape is irregular due to swelling and edema. Anthropometric measurements show edema present as the stump circumference is 45.5cm. In comparison, the right limb thigh circumference is 37cm and 40cm relative to measuring +10cm and +15cm above the knee, respectively. The stump is 12cm shorter than the right thigh length.

During the fascia testing, areas of restricted mobility and tightness were observed. The Fascia latae and ITB, adductors, pectorals and thoracolumbar regions were found to be restricted bilaterally. In addition, reduced mobility was observed in the fascia bilaterally in the lumbar region, with some discomfort experienced on the left side. The quadriceps femoris showed restriction on the left side and yielding on the right, while the arms and hamstrings were yielding bilaterally. It is common for the fascia surrounding affected muscles to become tight after surgery, which can lead to reduced flexibility and ROM.

The posture examination revealed elevation of shoulders and significant head protrusion in both sitting and standing, and the patient has a kyphotic back (taken from 09.01.2023). The patient appears to have upper crossed syndrome (according to Janda),

as the pectoral muscles, upper trapezius, and levator scapulae have been found to be tight, and the lower trapezius to be hypotonic.

During sensation testing, the left lower extremity exhibited decreased sensitivity compared to the right side, with varying levels of discomfort and occasional moments of more intense pain, typically described as burning or tingling sensations lasting from several minutes to an hour. These symptoms occurred multiple times a day. The joint position and kinesthetic sense were found to be unaffected on the right side. Testing of the healthy limb was performed to assess whether the amputation had affected proprioceptive feedback, which can result in sensory deficits and altered motor control.

Upon muscle tone palpation, it was determined that the deltoids, quadriceps femoris group, gluteus maximus, medius, and minimus displayed bilateral hypotonicity. On the other hand, the right triceps surae, as well as the bilateral SCM, pectoralis major and minor, levator scapular, and trapezius muscles, were found to be hypertonic. Trigger points were discovered on the left levator scapulae at the insertion point on the superior angle of the scapula and on the left trapezius at the posterior border, approximately 2cm from the base of the neck and another midpoint about 3cm from the spine. The right trapezius exhibited two adjacent trigger points in the upper trapezius region, roughly midway between the neck and shoulder. The paravertebrals exhibited bilateral hypertonicity, with a trigger point located approximately 1.5cm to the midline at the level of L3-L4 on the left side. Furthermore, the TFL, adductors, and hamstrings group showed hypotonicity on the left side but hypertonicity on the right side.

The patient's weight has gone from 79kg on the day of hospitalization to 70kg on the day of the amputation surgery. The final weight will be done approximately seven days after the surgery once the edema has subsided.

The breathing pattern was analyzed in a supine position only. Breathing is dominant in the abdomen. No accessory muscles are used, and the chest is symmetrical in shape.

Three movement patterns were examined over two days: Hip ABD and shoulder ABD on 10.01.2023 and Hip EXT on 11.01.2023. The Hip ABD on the right side did not show hip hiking or EXT ROT. However, hip FLX tended to suggest tight psoas and perhaps weaker gluteus medius, and the ROM was overall limited. During shoulder ABD, bilateral shoulder elevation was observed at approximately 50^{o} due to overactive upper trapezius and levator scapulae. The patient has a forward head and protracted shoulders.

Below the right scapula is a 10cm scar from a lung surgery where one lobe has been removed. Hip EXT was performed bilaterally. The ipsilateral synergistic erector spinae contracts earlier than the primary mover - gluteus maximus to initiate hip EXT, altering the movement pattern on both the left and right sides. Hip EXT ROM is restricted on the left side (measured 10º on in the third therapy unit), possibly due to the tight psoas. Due to the erector spinae initiating the movement, there can be stress on the lumbar spine, resulting in pain.

A gait examination was done two times — the first on 10.01.2023 in a high walker and the second on 12.01.2023 on crutches. In the walker, the distance covered was approximately 4m. The patients' steps had a smaller stride length; however, they were not hops or jumps but attempts of an actual step. The left hip is in approximately 15º FLX. The patient's first time on crutches went very well, and he also walked about 4m with the support of two physiotherapists. His upper body strength is an advantage. The patient was relatively stable and upright. The head protrusion is still significant. His left limb stump tends to still be in about 15º FLX, and his right limb knee FLX is good in the initial swing phase. The patient must focus on placing the end of the crutches in the same line and wide enough to fit his step in.

3.3 Short-term and long-term physiotherapy plan

Short term

This would be 1 – 6 weeks post-surgery and would involve:

1. **Pain management** – the primary aim is to manage the pain and discomfort as of day 1 post-surgery. This is primarily done through medications and a pain management plan given by the doctor
2. **Wound care** – the wound is monitored for any infections, and bandaging and dressing are kept clean
3. **Mobility and physical therapy** – the aim is to strengthen and re-educate the muscles, stretch shortened muscles, and regain mobility and functionality to be independent.
4. **Deep vein thrombosis prevention** – done through passive, active-assisted, and active movements
5. **Gait re-education** – the aim is to verticalize the patient as soon as possible and get them to re-learn how to walk again

Long term

This would be six or more weeks post-surgery and include the same as above but progressing in difficulty and demand. Additionally, there will be:

1. **Prosthetic fitting and training -** an essential part of the long-term plan. The individual will need to work with a prosthetist to find the best prosthetic for their needs and learn how to use it.
2. **Lifestyle modifications -** Depending on the individual's specific needs and lifestyle, they may need to modify their living environment, work, and leisure activities to accommodate their condition.
3. **Psychological support -** The individual may experience emotional challenges related to their condition, and psychological support, such as counseling or support groups, may be beneficial
4. **Follow-up appointments** - Regular follow-up appointments with their healthcare provider to monitor their progress, address any issues that arise, and adjust the plan as necessary

3.4 The daily record of therapy progress

3.4.1 First Therapy Unit, 06.01.2023 – Day 1 post operation

Brief assessment

Subjective:

- PLP – pins and needles feeling on the 'shin,' feeling tired and frustrated, had pain in the morning and was given painkillers

Objective:

- The patient is less than 24 hours post-amputation, stump edema, and the wound is in a clean and dry bandage. The patient is in a bad mood. The right leg is of average temperature, with minor skin color changes in some areas of the foot, most likely due to PAD and slightly poorer blood circulation. The patient has an epidural.

Aim and therapy proposed:

- Check the current situation post-op and conduct an initial kinesiological examination (see above)
- To begin building a mutual trust
- Release fascia gently
- Do AROM exercises in supine position/ DVT prevention

Therapy performed, and results:

- **Initial kinesiological examination** – see above
- **Fascia release –** pectorals, left quadriceps femoris, adductors, and ITB gently
- **AROM exercises**
    - **LE –** Supine static glute contraction; hip FLX; right hip ABD; right knee FLX/ EXT; right ankle all movements
    - **UE –** All finger and wrist movements; elbow FLX/ EXT; shoulder ABD/ ADD/ FLX/ IR/ ER in supine

'Situations':

- Strength testing was not conducted on the left side due to the pain

Self-therapy:

- **Right LE**
  - 4x10 ankle circle, dorsi-/plantar-FLX
  - 4x10 knee FLX/EXT
  - Supine static glute contractions
- **Left LE**
  - 1x5 knee 'EXT'/ static quadriceps contractions
- **Breathing exercise -** place hands on the abdomen and breathe into it 3x, then place on the lower thoracic and breathe into hands laterally 3x and finally place on chest and breath into hands 3x

Evaluation of therapy effect:

Patient POV:

- He is finding it difficult to see the light at the end of the tunnel after being hospitalized in November

Physiotherapist POV:

- Managed to do the majority of the assessments planned. The patient is quite pessimistic but cooperated. His mood improves when he can do what is asked; however, before trying already says he cannot do it.

3.4.2 Second Therapy Unit, 09.01.2023 – Day 4 post operation

Brief assessment

Subjective:

- The patient says he has been exercising in bed. He is feeling more enthusiastic.

Objective:

- The patient sat down with a colleague on 07.01.2023. The patient is in a better mood. There is stump edema. The wound is in a clean and dry bandage. The right leg is the same as in the first therapy unit. The patient has an epidural.

Aim and therapy proposed:

- Fascia release
- AROM exercises and try to exercise in a side-lying position for hip EXT and hip ABD
- Stretching of the iliopsoas
- Practicing transfers from supine to sitting to standing
- If stable, try to take a few steps on a high walker.
- Control breathing pattern in sitting and potentially standing
- Check posture in sitting and standing

Therapy performed, and results:

- **Additional Initial kinesiological examination** – see above
- **Fascia release –** pectorals, left quadriceps femoris, adductors and ITB gently
- **AROM exercises**
    - **LE –** Same as the first therapy unit
        - Additional exercises in side lying on the right side completed: Hip FLX/ EXT and ABD
    - **UE –**Same as the first therapy unit
    - Done with a focus on inhalation and exhalation
- **Stretching -** left iliopsoas in side lying

- **Transfers**
  - **Side-lying:** can do without help and currently sleeps on his right side.
  - **Sit**: Can sit up on his own, with no problems. He is stable when seated. Slightly dizzy. Correction of foot position (below knee IR). Correction of posture – shoulders slumped, back hunched and chest collapsed down.
  - **Standing:** with the help of a high walker and physiotherapist. The patient was dizzy and tried lifting his foot and placing it on the spot. He is tired.
- **Breathing pattern**
  - **Sit:** abdominal breathing dominant, no accessory muscles used
  - **Stand:** abdominal breathing dominant, accessory muscles slightly used
  - **Exercise –** breathing into the abdomen, lower and upper thoracic
- **Posture examination**
  - In the sitting and standing positions, shoulders are elevated and the head protrudes significantly forward the kyphotic back.

'Situations':

- No steps were taken, standing was not stable enough and the patient was slightly dizzy.

Self-therapy:

- Continue with exercises from the first therapy unit, including the breathing exercise + the additional side-lying position exercises. Focus on inhalation and exhalation in the movements.

<u>Evaluation of therapy effect:</u>

Patient POV:

- He was happy to stand up but disappointed that he felt tired and dizzy.

Physiotherapist POV:

- The majority of planned assessments. The sitting transfer went well. The patient has strength. Must work on upper body posture in sitting and standing. AROM is a lot better as the pain has reduced

3.4.3 Third Therapy Unit, 10.01.2023 – Day 5 post operation

Brief assessment

Subjective:

- Less pain is felt in the stump, is frustrated by being connected to various monitors. He complains about being in the hospital too long and wanting to go home finally. Pain in the lumbar spine from lying in bed so much for so long

Objective:

- Edema of the stump. The wound is in a clean and dry bandage—no changes on the right leg.

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine and side-lying
- Movement pattern hip ABD and shoulder ABD
- Breathing exercise
- Turning into the prone position
- Stretching of iliopsoas and upper trapezius
- Transfers from supine to sitting to standing
- Attempt to take a few steps on a high walker. If stable
- Goniometry measurements

Therapy performed, and results:

- **Additional Initial kinesiological examination** – see above
- **Fascia release –** pectorals, left quadriceps femoris, adductors and ITB gently
- **AROM exercises**
    - **LE –** Same as the second therapy unit
        - Additional exercises in prone completed: Hip EXT
    - **LE –** Same as the first therapy unit
    - Done with a focus on inhalation and exhalation
- **Stretching -** left iliopsoas in side lying and upper trapezius

- **Transfers**
  - **Prone:** first time to turn on his stomach, some difficulty at first – not due to physical limitations but more of a mental block. He said he could not do it and would not do so connected to all the cables. After explaining why it is essential to lie down prone during rehabilitation, the patient turned over with no problem after correctly positioning his right arm overhead to ease the turning. Once prone, I would gently press on the left SIPs to help get the pelvis in contact with the bed. Fixing the sacrum hip EXT was performed. The strength in the glutes is good.
  - **Sit**: Done on own smoothly. Correction of foot position (below knee INT ROT) and posture correction – shoulders slumped, back hunched and chest collapsed down – must be reminded. Not dizzy.
  - **Standing:** with the help of a high walker and physiotherapist. Not dizzy. Balance is better than yesterday. The patient also feels secure in his stance.
- **Movement pattern**
  - **Hip ABD** was conducted only on the side lying on the right side – no hip hiking or ER is visible. However, hip FLX suggests tight psoas and perhaps weaker gluteus medius. The ROM is restricted.
  - **Shoulder ABD** was conducted. There is shoulder elevation bilaterally at approximately 50^{o} due to overactive upper trapezius and levator scapulae. The patient has a forward head and protracted shoulders. Below the right scapula is a 10cm scar from a lung surgery where one lobe has been removed.
- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic
- **Gait**
  - Distance covered approximately 4m. steps on the smaller stride length. However, they are not hops or jumps but attempts of an actual step.
  - Left hip is in approximately 15^{o} FLX

- **Goniometry, AROM**

Joint	Plane	Left (º)	Right (º)
Hip	S	10 – 15 – 85	15 – 0 – 105
	F	10 – 0 – 20	20 – 0 – 35
	R	X	30 – 0 – 40
Knee	S	X	0 – 0 – 110
Ankle	S	X	25 – 0 – 45
	T	X	25 – 0 – 45
Shoulder	S	30 – 0 – 165	30 – 0 – 170
	F	X – 0 – 90	X – 0 – 90
	R	60 – 0 – 45	60 – 0 – 50
Elbow	S	0 – 0 – 140	0 – 0 – 145
	T	80 – 0 – 80	80 – 0 – 80
Wrist	S	75 – 0 – 75	70 – 0 – 65

Table 18: AROM goniometry measurements – third therapy unit

Self-therapy:

- Continue as in the second therapy session

Evaluation of therapy effect:

Patient POV:

- He was pleased and accomplished as he had complained he would not be able to take any steps today, even before trying. He feels more hopeful.

Physiotherapist POV:

- It was an excellent therapy unit. The transfers were smooth, and the patient was not dizzy. More steps taken/ distance covered than expected

3.4.4 Fourth Therapy Unit, 11.01.2023 – Day 6 post operation

Brief assessment

Subjective:

- The patient is in a good mood. He slept well and is not connected to so many tubes anymore – he only has the blood pressure sleeve and ECG. He was looking forward to today's therapy. However, he has pain in his lumbar spine. Feels PLP more frequently today – mild to moderate pain, in particular, a burning feeling

Objective:

- He looks well-rested. Stump full bandaging is gone, only a large clean plaster, minor speckling—no changes on the right leg.

Aim and therapy proposed:

- AROM exercises in supine, side-lying and prone
- Fascia release
- Movement pattern hip EXT
- Breathing exercises
- Strengthening
- Stretching the iliopsoas and upper trapezius
- Transfers from supine to sitting to standing
- Walking in high walker
- Exercises in a high walker – standing on tiptoe, stump hip EXT and hip ABD
  New weigh in

Therapy performed, and results:

- **Additional Initial kinesiological examination** – see above
- **Fascia release –** Thoracolumbar region and lumbar region
- **AROM exercises**
  - **LE –** Same as the third therapy unit
    - Additional exercises in prone completed: Hip EXT
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation
- **Stretching -** left iliopsoas in side lying and upper trapezius

- **Strengthening**
  - Hip ABD and ADD against slight resistance; Clamshell for left hip ABD
  - Water bottle overhead presses, lateral raises, bicep curls

- **Transfers**
  - **Prone:** smoother transfer into prone, still needs to focus on pushing the left SIAS into the bed to lay entirely flat in prone.
  - **Sit**: Done on own smoothly. Correction of foot position (below knee INT ROT) and posture correction – shoulders slumped, back hunched and chest collapsed down – must be reminded. Not dizzy.
  - **Standing:** Can stand on the high walker without assistance. Not dizzy. The patient is stable in this position. Standing more upright, but head protrudes significantly—exercises are done in the walker – standing on tiptoe 10x, stump hip EXT and hip ABD 10x. The exercises went well. Standing on tiptoes caused no problem. The hip ABD went smoothly. Hip EXT required some work at first instance to coordinate himself in the movement and to do so without leaning forward with his body.

- **Movement pattern**
  - **Hip EXT** was performed bilaterally. The ipsilateral synergistic erector spinae contracts earlier than the primary mover - gluteus maximus to initiate hip EXT, altering the movement pattern on both the left and right sides. Hip EXT ROM is restricted on the left side (measured 10^{o} in the third therapy unit), possibly due to the tight psoas. Due to the erector spinae initiating the movement, there can be stress on the lumbar spine, resulting in pain.

- **Weighing -** patients' weight 6 days post operation is **59.0kg.**

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
    - Distance covered approximately 10m in a high walker. Steps still on the smaller stride length, attempt to keep an upright posture. Stable.
    - Left hip is in approximately 15º FLX

Self-therapy:

- Repeat exercises are done in therapy sessions in bed

Evaluation of therapy effect:

Patient POV:

- The patient is glad that the transition to prone is manageable but still uncomfortable. Felt a little out of breath at the end of walking on a high walker

Physiotherapist POV:

- It was an excellent therapy unit. The transfers were smooth and the patient was not dizzy. More distance was covered than expected, and the gait pattern was not too bad – the patient did FLX his right knee during the initial swing phase. He also makes actual steps and does not jump or drag his right foot. What we need to work on is the left hip EXT. The stump tends to FLX forward. The patient tends to stand hunched forward with his shoulders. However, when reminded and with cueing, he attempts to correct this by standing more upright. The patient has the advantage of having strength in his upper body and extremities.

3.4.5 Fifth Therapy Unit, 12.01.2023 – Day 7 post operation

Brief assessment

Subjective:

- Great mood, has been moved to the ‘’standard’’ department and is very happy to be here. 1st night he has not taken painkillers for pain sleep or in the morning. He is excited to walk more.

Objective:

- He is in a good mood. It still has some minor speckling on the bandage—no changes on the right leg.

Aim and therapy proposed:

- AROM exercises in supine, side-lying, and prone – including new exercise in prone for back EXT
- Fascia release
- Breathing exercises
- Strengthening
- Stretching the iliopsoas (PIR), upper trapezius (PIR) and right triceps surae
- Transfers from supine to sitting to standing
- Walk in high walker
- Attempt to walk with crutches
- Wheelchair measurements

Therapy performed, and results:

- **Additional Initial kinesiological examination** – see above
- **Fascia release –** as in the fourth therapy unit
- **AROM exercises**
  - **LE –** Same as the fourth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying -PIR, upper trapezius – PIR and triceps surae

- **Strengthening**
  - Hip ABD and ADD against slight resistance; Clamshell for left hip ABD
  - Theraband seated rows, seated tricep EXT – push into bed

- **Transfers**
  - **Prone:** much better transfer, no problems to lie prone
  - **Sit**: Done on own smoothly. Correction of foot position (below knee INT ROT) and posture correction – shoulders slumped, back hunched and chest collapsed down – must be reminded. Not dizzy.
  - **Standing:**
    - Firstly, with the help of a high walker. Not dizzy, very stable, no aid from physiotherapist.
    - After lunch, we went for a walk with crutches. Very little help is required when getting up using one crutch. Stable once standing in crutches. The knee is EXT.

- **Wheelchair -** Tried at 48cm width wheel-chair, measured to see what would be best for the patient = 43cm width (so there is some space on either side so a bigger coat he may wear could fit)

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Distance covered approximately 20m in a high walker. Steps stride length has improved. Attempt to keep an upright posture. Stable. No supervision is required. The patient can independently walk in the high walker.
  - Left hip is in approximately 15º FLX
  - Use of crutches the first time. Upper body strength is an advantage, with the supervision of 2 physiotherapists holding under the armpit for support – walked about 4m. relatively stable and upright. The head protrusion is significant. His left limb stump tends to be in about 15º FLX. Right limb flexes knee well in initial swing phase. He must focus on placing the end of the crutches in the same line and wide enough to fit his step in.

Self-therapy:

- Repeat exercises are done in therapy sessions in bed.

Evaluation of therapy effect:

Patient POV:

- He is delighted today and feeling hopeful. He is proud of himself for walking the distance on crutches and is glad that he will be more mobile once a wheelchair is placed in his room.

Physiotherapist POV:

- It went very well. For the first time on crutches, the patient managed to stay stable and walk about 4m. However, we will need to work on CV fitness and continue with breathing-focused exercises, as the patient was out of breath after walking the distance on crutches.

3.4.6 Sixth Therapy Unit, 13.01.2023 – Day 8 post operation

Brief assessment

Subjective:

- He feels good, minus the low back pain. He is feeling positively emotional. He now has a wheelchair and high walker in his room and can be more independent.

Objective:

- The patient appears happy that he is more mobile. He still feels pain in the lower back from lying a lot. It still has some minor speckling on the bandage. Stump edema appears to have gone down. No change in the right leg

Aim and therapy proposed:

- AROM exercises in supine, side-lying and prone
- Release fascia
- Breathing exercises
- Strengthening
- Stretching the iliopsoas and upper trapezius with PIR, triceps surae
- Transfers from supine to sitting to standing
- Walk in high walker
- Walk in crutches
- Given a rental wheelchair for the time being – practice transfer and educate on usage.

Therapy performed, and results:

- **Fascia release –** as in the fourth therapy unit, focus on the lumbar and thoracolumbar region
- **AROM exercises**
  - **LE –** Same as the fifth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying and upper trapezius – PIR, triceps surae
- **Strengthening**
  - Hip ABD and ADD against slight resistance; Clamshell for left hip ABD
  - Theraband seated rows, seated tricep EXT – push into bed

- **Transfers**
  - **Prone:** the patient is starting to feel more comfortable lying prone and feels relief from the lower back in this position.
  - **Sit**: Done on own smoothly. The patient is more aware of his sitting posture and tries to correct his foot and upper body posture. Not dizzy.
  - **Standing:**
    - Firstly, with the help of a high walker. Not dizzy, very stable, no aid from physiotherapist.
    - After lunch, we went for a walk with crutches. No help is required when getting up using one crutch. Stable once standing in crutches. Knee is EXT

- **Wheelchair**
  - Education of transfer from bed to the wheelchair – the patient did it with ease

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Distance covered approximately 20m in a high walker. Steps still on the smaller stride length, attempt to keep an upright posture. Stable.
  - Left hip is in approximately 15º FLX
  - Walked about 10m in crutches, supervision of two physiotherapists – holding under armpit for support. However, better positioning of the crutches still tends to go beyond the ‘’line’’ with his foot. He is more stable than yesterday. The head protrudes—required cues to keep upright.

Self-therapy:

- Repeat exercises are done in therapy sessions in bed.
- Use a wheelchair to be independent and use a high walker for walks, focusing on upright posture and making steps instead of using the pushing wheels to move forward. The aim is to walk more often, build up CV fitness, focus on upright posture and correct gait pattern. Also, he needs to remind himself that he must do stump hip EXT and not keep FLX at all times during the gait.

Evaluation of therapy effect:

Patient POV:

- The patient looks forward to walking in the high walker and using the wheelchair over the weekend. He feels confident independently in the high walker. The crutches are challenging but he is determined to get it right.

Physiotherapist POV:

- Great therapy session today, the patient is making significant progress and everything is going according to plan. CV fitness and endurance are essential so the patient can have enough energy to use crutches as they are energy-taxing. Strength needs to be worked on as well.

3.4.7 Seventh Therapy Unit, 16.01.2023 – Day 11 post operation

Brief assessment

Subjective:

- He no longer had pain at night and has not taken nightly pain meds during the weekend. Feeling good, he walked on the weekend using the higher walker up and down the corridor. Less LBP – has been lying prone and walking in a high walker to relieve the pain.

Objective:

- The patient seems rested and eager to walk with crutches. The bandage is clean—no changes to the right leg.

Aim and therapy proposed:

- AROM exercises in supine, side-lying and prone
- Fascia release
- Breathing exercises
- Strengthening
- Stretching the iliopsoas and upper trapezius – PIR, levator scapulae
- Transfers from supine to sitting to standing
- Walk in crutches

Therapy performed, and results:

- **Fascia release –** as in the fourth therapy unit
- **AROM exercises**
  - **LE –** Same as the sixth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying and upper trapezius – PIR, levator scapulae

- **Strengthening**
  - Clamshell for left hip ABD with slight resistance
  - Seated tricep EXT – push into bed, water bottle lateral raises and bicep curls

- **Transfers**
  - **Prone:** the patient is starting to feel more comfortable lying prone and feels relief from the lower back in this position.
  - **Sit**: Done on own smoothly. The patient is more aware of his sitting posture and tries to correct his foot and upper body posture. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Distance covered approximately 20m using crutches with the supervision and support of two physiotherapists. Attempt to keep an upright posture. Stable. Still uncertain about his stability. Two smaller breaks towards the end to recover a bit. The patient positions crutches well, with minor faults, but is aware of and corrects them. He needs to focus and not make those mistakes fully. The head protrudes and requires cueing.
  - The left hip is still in approximately 15^{o} FLX. However, the patient attempts to EXT the hip more.

Self-therapy:

- Repeat exercises are done in the therapy session
- Continue using the high walker for walks, focusing on an upright position and building CV fitness

Evaluation of therapy effect:

Patient POV:

- The patient is happy to be back on crutches again, motivated to feel confident, start walking without supervision, and get on the stairs as soon as possible. He wants to go home.

Physiotherapist POV:

- The patient is motivated to get home as soon as possible. He takes on all cues and instructions and implements them directly.

3.4.8 Eighth Therapy Unit, 17.01.2023 – Day 12 post operation

Brief assessment

Subjective:

- He is feeling down today – he has been in the hospital for about two months and feels defeated. He said he had been in the hospital for so long when the doctors tried to save his leg, and all that time and effort was wasted. He feels so much time and effort will be put into this rehabilitation process now, which may all be useless in the end, that he will not manage to walk independently in crutches or get a prosthetic soon. PLP is very frequent and painful.

Objective:

- The patient is in a poor mood and very emotional, from mad and frustrated to sad and hopeless. The bandage is clean. No changes with the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas, upper trapezius and levator scapulae – PIR
- Transfers from supine to sitting to standing
- Walk in crutches

Therapy performed, and results:

- **Fascia release –** left quadriceps femoris, Adductors, ITB and pectorals
- **AROM exercises**
  - **LE –** Same as the seventh therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying, upper trapezius and levator scapulae – PIR

- **Strengthening**
  - Hip ABD and ADD against slight resistance, hip EXT slight resistance, static quadriceps contractions.
  - Theraband seated rows, water bottle front raises

- **Transfers**
  - **Sit**: Done on own smoothly. The patient is more aware of his sitting posture and tries to correct his foot and upper body posture. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Distance covered approximately 10m today using crutches with the supervision of two physiotherapists. The patient is tired and not motivated. Unable to keep an upright posture. The patient is still stable. The head protrudes and requires cueing.
  - Left hip in FLX. He was less aware today, had to remind him to correct it.

'Situations':

- Shorter distance walked on crutches as the patient was not in the correct headspace.
- He refused to lie down prone today. Reasons ranged from ''I do not feel like it today, my back hurts, and there is no point.''

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue with the practice of gait in high walker

Evaluation of therapy effect:

Patient POV:

- The patient is tired and out of breath. Not feeling good about the session, believes it went extremely poorly and even as a setback.

Physiotherapist POV:

- Although the session did not go as planned today, the patient is notably more stable on the crutches

3.4.9 Ninth Therapy Unit, 18.01.2023 – Day 13 post operation

Brief assessment

Subjective:

- He slept well and visited his wife the other day after lunch. Feels cheered up and motivated to continue to progress. PLP is less frequent with shorter durations today. The pain is less intense than yesterday.

Objective:

- It is visible that the patient is feeling a lot better compared to yesterday. The bandage is clean. No changes to the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas, upper trapezius and levator scapulae – PIR
- Transfers from supine to sitting to standing
- Walk in crutches

Therapy performed, and results:

- **AROM exercises**
  - **LE –** Same as the eighth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying, upper trapezius and levator scapulae – PIR

- **Strengthening**
  - In high walker – hip ABD, hip EXT, standing calf raise
  - Seated tricep EXT – push into bed, waterbottle biceps curls, Theraband seated row

- **Transfers**
  - **Prone:** good transfer with no problem, exercise performed in this position
  - **Sit**: Done on own smoothly. Better correction of posture and foot position. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Distance covered approximately 20m again using crutches with the supervision and support of 2 physiotherapists. The patient is feeling tired and not motivated at all. Attempt to keep an upright posture is worse. The patient is still stable. Increased uncertainty about his stability. The head protrudes and requires cueing.
  - Left hip FLX, more aware about it again and only tried to correct when realized on own, otherwise corrected with cueing

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue with the practice of gait in high walker

<u>Evaluation of therapy effect:</u>

Patient POV:

- The patient is happy he managed the whole corridor there and back again. However, he is tired and out of breath.

Physiotherapist POV:

- The therapy went well. The walking in crutches is stable, with only one minor break to recover towards the end of the corridor.

3.4.10 Tenth Therapy Unit, 19.01.2023 – Day 14 post operation

Brief assessment

Subjective:

- The patient slept worse tonight. However, he has no pain and wants to try the stairs.

Objective:

- The patient has been progressing well since the surgery. Overall, he has control and is stable on crutches. The bandage is clean and the edema appears to have gone down again. No changes with the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas – PIR
- Transfers from supine to sitting to standing
- Walk in crutches
- Attempt stairs, 3/4 steps up and down

Therapy performed, and results:

- **Fascia release –** left quadriceps femoris, adductors and ITB gently
- **AROM exercises**
  - **LE –** Same as the ninth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying -PIR

- **Strengthening**
  - In high walker – hip ABD, hip EXT, semi-squats

- **Transfers**
  - **Prone:** good transfer with no problem, exercise performed in this position
  - **Sit**: Done on own smoothly. Better correction of posture and foot position. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT
- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic
- **Gait**
  - Used the wheelchair to get to the staircase. With the support of 2 physiotherapists, four steps up and down were achieved. Going up went very well. He was less confident going down, but the overall performance was great for a first go on the stairs. After the stairs, the patient returned to the room using the crutches with two minor breaks for recovery. The distance was about 20m. There was the support of 1 physiotherapist. Attempt to keep an upright posture is worse. The patient is still stable. The head protrudes and requires cueing.
  - Left hip EXT is corrected when cued.

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue with gait practice in high walker

<u>Evaluation of therapy effect:</u>

Patient POV:

- He was delighted he managed the stairs but is worried about eventually going down the stairs without supervision**.**

Physiotherapist POV:

- The technique on the stairs was good. However, going downstairs, we need to build more confidence and slow down so there is room to think and place the crutches properly.

3.4.11 Eleventh Therapy Unit, 20.01.2023 – Day 15 post operation

Brief assessment

Subjective:

- Has already walked with the walker this morning and done the exercises in the walker. Felt like he had plenty of energy. Few moments of PLP and mild discomfort.

Objective:

- The patient looks well-rested. The bandage is clean. No change in the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas, upper trapezius, levator scapulae – PIR, SCM, triceps surae
- Transfers from supine to sitting to standing
- Walk in crutches
- Attempt stairs, 4/5 steps up and down

Therapy performed, and results:

- **Fascia release –** left quadriceps femoris, adductors and ITB gently,
- **AROM exercises**
  - **LE –** Same as the tenth therapy unit
  - **LE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying, upper trapezius and levator scapulae – PIR, triceps surae

- **Strengthening**
  - In high walker – hip ABD, hip EXT, standing calf raise

- **Transfers**
  - **Prone:** good transfer with no problem, exercise performed in this position
  - **Sit**: Done on own smoothly. Better correction of posture and foot position. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Used the wheelchair to get to the staircase. 2 physiotherapists supported going 11 steps up and down. Going up was good technically. Going down, the patient took more time to do the steps allowing for better technique.
  - Walked back to the room on crutches. Four short breaks are needed towards the end to recover. He was adamant about finishing by walking there on crutches. Attempt to keep an upright posture. The patient is still stable. The head protrudes and requires cueing.
  - Left hip EXT appeared to have improved. Less cueing required

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue with gait training and endurance training in high walker

<u>Evaluation of therapy effect:</u>

Patient POV:

- He felt good after completing a set of stairs and felt more confident on crutches.

Physiotherapist POV:

- Therapy was very successful. The patient did a complete staircase up and down and managed to walk back to the room on crutches with minimal support from one physiotherapist. Over the weekend, he will continue using the wheelchair and high walker.

3.4.12 Twelfth Therapy Unit, 23.01.2023 – Day 18 post operation

Brief assessment

Subjective:

- Over the weekend walked in the high walker a lot. Feeling less out of breath. Lying more often prone to relieve back. Is eager to go home already.

Objective:

- The patient appears to be in a good mood and has no pain. The bandage is clean. No change in the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas – PIR
- Transfers from supine to sitting to standing
- Walk in crutches
- walking stairs, 11 steps up and down (flight of stairs)

Therapy performed, and results:

- **Fascia release –** Thoracolumbar region and lumbar region
- **AROM exercises**
  - **LE –**Same as the eleventh therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying -PIR

- **Strengthening**
  - Hip EXT with resistance, hip ABD with resistance, static knee EXT contractions
  - Seated tricep EXT – push into bed, Theraband seated row, water bottle lateral raises.

- **Transfers**
  - **Prone:** good transfer with no problem, exercise performed in this position
  - **Sit**: Done on own smoothly. Better correction of posture and foot position. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Used the wheelchair to get to the staircase. With the support of 2 physiotherapists, 11 steps up and down were achieved. The patient feels confident going upstairs but still struggles with confidence going down the stairs.
  - Walked back to the room using the crutches. This time only one short break was needed to recover. Attempt to keep an upright posture. The patient is still stable. The head protrudes and requires cueing. Supervision of one physiotherapist was required with very little support.
  - Left hip EXT improved. Less cueing is required as the patient focuses more.

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue using the high walker and crutches for short distances in his room

<u>Evaluation of therapy effect:</u>

Patient POV:

- Feeling more optimistic about the stairs and being able to manage once home. The patient has six steps to enter his home with a railing. Walking in crutches is becoming better, and he does not run out of breath so quickly.

Physiotherapist POV:

- The patient takes the therapy very seriously. On the weekend, he really aimed to increase his CV fitness and endurance. He has also been practicing his breathing pattern, especially in supine and sitting.

3.4.13 Thirteen Therapy Unit, 24.01.2023 – Day 19 post operation

Brief assessment

Subjective:

- He is looking forward to practicing on crutches, wants to go home as it is finally taking too long, and is becoming impatient. Mild PLP, duration is short, generally a few minutes, but frequent.

Objective:

- The patient is eager to begin his therapy. He appears to feel more confident. The bandage is clean. No change in the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas, upper trapezius, levator scapulae, SCM
- Transfers from supine to sitting to standing
- Walk in crutches
- walking stairs, 1 flight of stairs up and down

Therapy performed, and results:

- **Fascia release –** Thoracolumbar region and lumbar region
- **AROM exercises**
  - **LE –** Same as the twelfth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying, upper trapezius, levator scapulae and SCM

- **Strengthening**
  - Clamshell with resistance, hip EXT with resistance, static glute contractions
  - Seated tricep EXT – push into bed

- **Transfers**
  - **Prone:** good transfer with no problem, exercise performed in this position
  - **Sit**: Done on own smoothly. Better correction of posture and foot position. Not dizzy.
  - **Standing:** stood up using one crutch without assistance. The patient is stable and confident in this transfer. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Used the wheelchair to get to the staircase. 1.5 flight of stairs was achieved. Going upstairs, minimal supervision of one physiotherapist was needed. Going downstairs required the support of two physiotherapists as the patient was still a little unstable.
  - Walked back to the room using the crutches. No breaks. Covered 20m, with only the last 10m with little support from one physiotherapist. Attempt to keep an upright posture. The head protrudes and requires cueing.
  - Left hip EXT has improved. Less cueing is required as the patient focuses on the position more.

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue using a high walker and using crutches in his room for short distances

<u>Evaluation of therapy effect:</u>

Patient POV:

- Feel proud of his progress and ready for the doctors to tell him he can go home and continue his rehabilitation. No pain. He plans to walk after lunch in the high walker and to practice some exercises in the walker.

Physiotherapist POV:

- The patient is progressing very well and is eager to leave the hospital soon. The patient is stretching and doing the exercises as told. He understands the importance of his rehabilitation and will do anything to keep the progress going forward

3.4.14 Fourteen Therapy Unit, 25.01.2023 – Day 20 post operation

Brief assessment

Subjective:

- He slept well, had no pain, and had already walked in the high walker

Objective:

- The patient was sitting upon arrival. His foot position was correct. His head and shoulders are still protruding forward. However, it appeared that his trapezius was less elevated and tense. The bandage is clean. No change in the right leg

Aim and therapy proposed:

- Fascia release
- AROM exercises in supine, side-lying and prone
- Breathing exercises
- Strengthening
- Stretching the iliopsoas – PIR
- Transfers from supine to sitting to standing
- Walk in crutches
- walking stairs, 1.5 flights of stairs up and down, focusing on walking downstairs to be as stable as possible

Therapy performed, and results:

- **Fascia release –** as in the fourth therapy unit
- **AROM exercises**
  - **LE –** Same as the thirteenth therapy unit
  - **UE –** Same as the first therapy unit
  - Done with a focus on inhalation and exhalation

- **Stretching -** left iliopsoas in side lying -PIR

- **Strengthening**
  - Static glute contractions, Hip ADD and ABD with resistance
  - Water bottle overhead presses, lateral raises, bicep curls, tricep extensions

- **Transfers**
  - **Prone:** will lie prone later as he is full from breakfast
  - **Sit**: Was already seated. When cued, he corrected his posture. The foot position was already correct upon arrival. Not dizzy
  - **Standing:** stood up using one crutch without assistance. Not dizzy, knee EXT

- **Breathing pattern**
  - **Exercise –** breathing into the abdomen, lower and upper thoracic

- **Gait**
  - Used the wheelchair to reach the staircase. 2 flights of stairs were achieved. Going upstairs, only the supervision of 1 physiotherapist was needed. Downstairs, some support was required due to instability. The last four steps down were the hardest. The patient tended to rush.
  - After the stairs, the patient managed to walk back to the room using the crutches with three short breaks and only supervision by the physiotherapist. Attempting to keep an upright posture is a lot better. Manages to do so for more extended periods. The head protrudes and requires cueing.
  - Left hip EXT significantly improved

Self-therapy:

- Repeat exercises are done in therapy sessions
- Continue using the high walker and using crutches for short distances in the room

<u>Evaluation of therapy effect:</u>

Patient POV:

- The patient feels confident enough to do very short distances independently on crutches. No back pain is present.

Physiotherapist POV:

- The patient feels more confident in his skills and is beginning to make the mistake of rushing, thus increasing the risk of poor crutch or foot placement and looking for stability.

3.4.15 Fifteen Therapy Unit, 26.01.2023 – Day 21 post operation

Brief assessment

Subjective:

- The main doctor visit came in and the patient feels thrilled as the wound is healing without complications - stitches will be removed tomorrow. He can go home to continue rehabilitation and start the desensitization process. He had walked in the room on crutches last night and went to the bathroom in crutches this morning.

Objective:

- The patient is looking rested and energized by the good news. The bandage is clean, and stump edema is significantly reduced. No change in the right leg

Aim and therapy proposed:

- Concluding kinesiological examination (unsure when stitches will come out tomorrow and if there will be enough time to do the final examinations)
- Stretching of the iliopsoas, upper trapezius, levator scapulae and right triceps surae – PIR
- If time and energy allow, walking the stairs with a focus on going downstairs in a stable manner will be done

Therapy performed, and results:

- **Final kinesiological examination**
    - **Breathing Pattern:** in all three positions (results in the following section)
    - **Muscle strength testing** (results in the following section)
    - **AROM goniometry** (results in the following section)
    - **Anthropometrics** (results in the following section)
    - **Movement pattern examination:** Hip EXT, hip ABD and shoulder ABD (results in the following section)

- **Gait examination** – in high walker, in crutches
    - Used the wheelchair to reach the staircase. 2 flights of stairs were achieved. Going upstairs, only supervision of 1 physiotherapist was minimally needed. Downstairs, support was required only on the final flight of stairs. The patient took his time and was a lot more stable.
    - He managed to walk on crutches for 10m and finished by wheelchair as he felt tired. Attempting to keep an upright posture is a lot better. Manages to do so for more extended periods. The head protrudes and requires cueing.
    - Left hip EXT significantly improved
- **Posture examination –** Attempts to correct posture in seated and standing. However, the shoulders are still elevated and the head protrudes forward. He can sit more upright for a longer period of time.

- **Stretching -** left iliopsoas in side lying, upper trapezius, levator scapulae and triceps surae – PIR

Self-therapy:

- Repeat exercises from therapy sessions
- Continue using a high walker and crutches in the room for short distances

Evaluation of therapy effect:

Patient POV:

- He is more confident in the stairs and is not worried that he will not manage at home as there are only a few steps to the entrance of his house

Physiotherapist POV:

- A final kinesiological examination was conducted, and many improvements were seen. The stairs went very well, and the patient was much more stable.

3.4.16 Sixteenth Therapy Unit, 27.01.2023 – Day 22 post operation

Brief assessment

Subjective:

- Plans on going home and continuing the rehabilitation process are being made, stitches have been taken out, and the patient feels good and excited

Objective:

- The scar is healing well. Some areas around the incision are slightly raised. The stump tends to shape towards a more uneven cylindrical form. Further rehabilitation will include bandaging and desensitization in order to shape the stump into an even cylinder for future prostheses. The stump is clean, with no speckling. The patient is in a very good mood. Today's therapy is the final one and will only be a walk on crutches as there was not enough time (a ''good bye final walk'')

Aim and therapy proposed:

- Fascia release
- Stretching of iliopsoas, upper trapezius, levator scapulae and SCM
- Walk on crutches with no support and see how far the patient can go.

Therapy performed, and results:

- **Fascia release** – as in the fourth therapy unit

- **Stretching -** left iliopsoas in side lying, upper trapezius, levator scapulae and SCM

- **Gait**
  - The patient walked about 20m without support and took one short break to recover. Attempting to keep an upright posture for extended periods is much better. However, the head protrudes and requires cueing.
  - Walked on crutches for 10m and then decided he wanted to finish by wheelchair as he was feeling tired. Attempting to keep an upright posture is much better, but he manages to do so for extended periods. However, the head protrudes and requires cueing.
  - Left hip EXT significantly improved

Self-therapy:

- Repeat exercises from therapy sessions
- Continue using a high walker and crutches in the room for short distances

Evaluation of therapy effect:

Patient POV:

- He feels like he can be independent again to a certain extent and believes getting a prosthesis soon is not impossible for him.

Physiotherapist POV:

- Successful rehabilitation up until today, the patient is independently mobile and will continue the process in order to get a prosthesis soon. Working with the patient went well overall. There were some difficulties here and there in cooperation as it was sometimes difficult to accept the situation or see hope in progress and change. However, the patient's strong will and mind made the rehabilitation process more successful.

3.5 Final kinesiological examination

Stump description: the stitches are out and the scar is healing well. Some areas around the incision are slightly raised. The stump tends to shape towards a more uneven cylindrical form.

Breathing Pattern:

- **Supine**: dominant abdominal breathing, no accessory muscles used, the chest is symmetrical
- **Sitting**: dominant abdominal breathing, no use of accessory muscles used. The chest is symmetrical.
- **Standing**: dominant abdominal breathing, no use of accessory muscles used, the chest is symmetrical.

Muscle strength (grading 0-5, according to Janda):

	Right limb	**Left limb**
Hip FLX	Grade 5	Grade 4
Hip ABD	Grade 5	Grade 4
Hip ADD	Grade 5	Grade 4
Hip EXT	Grade 5	Grade 4
Knee FLX	Grade 5	X
Knee EXT	Grade 5	X
Ankle dorsiFLX	Grade 5	X
Ankle plantarFLX	Grade 5	X
Ankle INV	Grade 5	X
Ankle EV	Grade 5	X

Table 19: Final kinesiological examination - Muscle strength tests

Anthropometrics

	Right limb (cm)	Left limb (cm)
Anatomical length	88	X
Functional length	91	X
Thigh + 10cm > knee circumference	37.5	X
Thigh + 15cm > knee circumference	40.5	X
Stump thigh circumference	X	42.5
Thigh length	44	X
Stump length	X	32
Knee circumference	35.5	X
Calf circumference	30.1	x

Table 20: Final kinesiological examination - Anthropometric measurements

AROM goniometry:

Joint	Plane	Left (°)	Right (°)
Hip	S	X – 10 – 100	X – 0 – 120
	F	15 – 0 – 35	25 – 0 – 45
	R	X	30 – 0 – 40
Knee	S	X	0 – 0 – 125
Ankle	S	X	25 – 0 – 45
	T	X	20 – 0 – 35*
Shoulder	S	30 – 0 – 165	30 – 0 – 170
	F	X – 0 – 90	X – 0 – 90
	R	60 – 0 - 45	60 – 0 – 50
Elbow	S	0 – 0 – 140	0 – 0 – 145
	T	80 – 0 – 80	80 – 0 -80
Wrist	S	75 – 0 – 75	75 – 0 – 70

Table 21: Final kinesiological examination - AROM goniometry measurements

All movements are done without pain.

Muscle tone palpation:

Muscle	Left	Right
Rectus femoris	Hypotonic	Mildly Hypotonic
Vastus lateralis	Hypotonic	Mildly Hypotonic
Vastus medialis	Hypotonic	Mildly Hypotonic
TFL	Hypotonic	Mildly Hypertonic
Adductors	Norm	Norm
Biceps brachii	Norm	Norm
Triceps brachii	Norm	Norm
Deltoid	Mildly Hypotonic	Mildly Hypotonic
Pectoralis minor	Hypertonic	Hypertonic
Pectoralis major	Hypertonic	Hypertonic
SCM	Hypertonic	Hypertonic

Table 22: Final kinesiologic examination - Muscle tone palpation

Neurological examination

Re-testing the sensation sense on the left lower extremity showed that the patient did feel the touch. However, it was less intense than on the right side. PLP was still present and would occur several times a day. The patient stated that the intensity was more frequently mild discomfort rather than severe pain. He still had some severe pain episodes, which would last some minutes. The feeling would be burning and tingling, and durations usually of 30 minutes.

Fascia

	Left	Right
Fascia lata and ITB	Mildly Restricted	Mildly Restricted
Adductors	Mildly Restricted	Yielding
Quadriceps femoris	Mildly Restricted	Yielding
Pectorals	Restricted	Restricted
Arms	Yielding	Yielding

Table 23: Final kinesiological examination – Fascia

Posture examination

- **Sitting:** Head and shoulder protraction. The shoulders tend to elevation. The chest falls inwards, the right foot points forward, and the knee is neutral with no rotation.
- **Standing:** Head and shoulder protraction. The shoulders tend to elevation. The chest falls inwards, and the right foot is slightly ABD, knee neutral with no rotation.

Movement pattern

- Hip EXT was performed bilaterally. **Right:** improvement in muscle order activation as the gluteus maximus initiates hip EXT (20^{o} ROM, therefore within the range of 10-30^{o}). **Left:** improvement is seen as well, with better activation of gluteus maximus, and the ROM is (ROM has improved to 15^{o}. No pain in movement bilaterally
- **Hip ABD.** on right side lying. No hip hiking, no ext rot, and the tendency for hip FLX is significantly reduced. ROM is not restricted anymore as it is now 35^{o} (30/50 is regular ROM)
- **Shoulder ABD** bilaterally – shoulder elevation does occur but not instead at approximately 50^{o}. It occurs at about 65^{o}. The patient's head still protracted forward and protracting shoulders.

Gait examination

	In high walker	In crutches
Initial contact	Heel strike present, loads laterally, knee FLX and ankle plantarFLX	
Loading response	Whole foot on the ground, five toes in contact	
Mid stance	Foot flat on the ground, knee EXT, left hip tendency for FLX but fixed with focus on it, late flat foot – COG passes over the foot.	Foot flat on the ground, knee tends to FLX, left hip tendency for FLX but fixed with focus on it, late flat foot – COG passes over the foot.
Terminal stance	Knee EXT. The left hip tendency for FLX, heels, and toe-off	The knee tends to FLX when the patient begins to rush with gait. The left hip tendency for FLX, heels, and toe-off
Pre-swing	Knee FLX, heel, and toe-off	Knee FLX
Full swing phase	Good knee EXT in the start of swing phase, no problem for hi FLX to propel forward	

Table 23: Final kinesiological examination - Gait examination

3.5.1 Exam conclusion

The stump stitches have been taken out, and the scar is healing well. Some areas around the incision are slightly raised. The stump tends to shape towards a more uneven cylindrical form. Further rehabilitation will be important to ensure an even cylindrical shape through desensitization and bandaging for future prostheses.

When observing the breathing pattern, abdominal muscles are dominant in supine, sitting, and standing. The accessory muscles are not used in any position.

During muscle strength testing, the right limb showed grade 5 for all muscles tested on the right limb, while the left limb hip FLX/ EXT/ ABD and ADD all tested as grade 4. The AROM showed that hip FLX on the left was 100º and on the right 120º, which is slightly limited and in the normal range of 120/135º, respectively. The left hip ADD is on the lower end of the ROM, but it is 10º less than on the right (15º vs 25º). Both hip ABD fall in the norm ROM, but the left is less by 10º. Finally, the plantarFLX of the right and left wrist are limited by 10º and 5º, respectively. Comparing the thigh circumferences, the right thigh is between 37.5 - 40.5cm depending on the location of the measurement (+10cm above knee and +15cm above knee, respectively). In comparison, the left thigh has a circumference of 43.2cm.

Muscle tone palpation resulted in the SCM, pectoralis major, and minor being bilaterally hypertonic.

When observing the movement patterns, the gluteus maximus initiates the movement on both sides during hip EXT, and the ROM falls within the norm. ROM is not restricted during hip ABD on the right side, and the hip FLX tendency is less. In shoulder ABD, shoulder elevation occurs bilaterally around 65º.

The head and shoulders are protracted in both sitting and standing. The shoulders also tend to elevation. During sitting, the right foot points forward, while the right foot is slightly ABD in standing. The patient appears to have upper crossed syndrome (according to Janda), in which the deep neck flexors and both the lower trapezius and serratus anterior would be weakened, and the upper trapezius, levator scapulae, and pectoral muscles tightened.

The gait examination was observed in the high walker and using crutches. Overall, the patient has a good foot movement stereotype following:

1. laterally loaded heel strike
2. flat foot
3. loading response with five toes in contact with the ground
4. late flat foot in which the COG passes over the foot allowing the body to move forward as the posterior muscles of the lower limb contract
5. midstance in which the knee tends to FLX a bit during crutches but is in EXT in the high walker. The foot is flat on the ground, but the left hip tends to FLX forward in both the high walker and on crutches (it is, however, fixed with awareness and cueing)
6. heel off
7. toe-off

There are no jumps or foot-dragging.

3.6 Evaluation of the effect of therapy

Throughout therapy, numerous significant changes have occurred:

Pain

From the start, the patient experienced PLP and was given pain medication and an epidural. In the third therapy unit, they reported lumbar pain due to prolonged lying in the supine position. They had their first pain-free night without pain medication on the day of the sixth therapy unit. By the seventh therapy unit, they had no pain at night and went an entire weekend without pain medication.

The patient reported experiencing PLP episodes ranging from mild discomfort to severe pain, which could last anywhere from minutes to an hour, several times a day. These episodes were typically characterized by a burning and tingling sensation. During the first and fourth therapy sessions, the PLP was more frequent and painful. By the eighth therapy unit, the patient experienced very frequent and severe intensity PLP, which left them feeling low and disheartened. However, in the following therapy unit, the patient's mood was uplifted by a visit from their wife, and as a result, the PLP became less frequent, of shorter duration, and less intense. On the eleventh therapy unit, there were only a few moments of mild discomfort associated with PLP, likely due to the patient's high activity level that day. By the thirteenth therapy unit, the patient only felt sporadic mild PLP episodes lasting a few minutes in length.

Muscle strength

In the first therapy unit, the right limb received a grade of 5 for all lower extremity muscle tests, except for knee FLX, which could not be tested due to the patient's inability to lie prone post-surgery. The left limb was not thoroughly tested in this therapy unit due to pain, but a contraction was observed during hip FLX and ABD. By the second therapeutic unit, this contraction was better, although still limited due to the pain. Once the pain subsided, left hip ABD remained relatively limited in strength. However, by the final kinesiological examination and end of the therapy units, the left limb Hip FLX, ABD, ADD, and EXT all received a grade 4.

Anthropometrics

In the first therapy unit, measurement of right thigh circumference was taken, with 37 and 40 cm, depending on the measurement location (+10 and +15 cm above the knee joint, respectively). The left thigh circumference was recorded as 45.5 cm. By the fifteenth therapy unit, the circumference of the left thigh was 42.5cm.

Breathing pattern

In the first therapy unit, the breathing pattern was only assessed in supine. Abdominal breathing was observed to be dominant, and no accessory muscles were engaged. Observation of the breathing pattern in seated and standing positions was examined in the second therapy session. Similarly, as with supine, abdominal breathing is dominant. However, in standing, there is some accessory muscle activation. By the fifteenth therapy unit, the breathing pattern was observed in all positions, including supine, sitting, and standing. The patient was observed to have a dominant abdominal breathing pattern in all positions, and accessory muscles were not used anymore in standing.

Posture

The patient's posture was assessed while sitting and standing in the second therapy unit. During sitting, there is IR below the right knee. The patient had a forward head position and elevated, protracted shoulders. Their back was also rounded, causing slouching when sitting for long periods. By the sixteenth therapy unit, the patient's posture was still rounded, with a forward head position, but their shoulders appeared to be less elevated and tensed. Although the shoulders were still protracted forward, the patient tried to sit upright and lift their chest, improving their posture in both seated and standing positions. There is no more IR below the right knee; the foot points forwards in seated and slightly ABD in standing.

The patient appears to have upper crossed syndrome (according to Janda), in which the deep neck flexors and both the lower trapezius and serratus anterior would be weakened and the upper trapezius, levator scapulae, and pectoral muscles tightened.

Muscle tone

Some muscular imbalances persisted, while others showed improvement or resolution. The initial examination revealed bilateral hypotonicity in the deltoids, quadriceps femoris group, gluteus maximus, medius, and minimus, which persisted in the final examination for the deltoids and left quadriceps group. However, the adductors had normal tone on both sides in the final examination, and the right gluteus maximus also had normal tone, while the left side improved from hypotonic to mildly hypotonic.

The initial examination also revealed hypertonicity in several muscles, including the bilateral SCM, pectoralis major and minor, levator scapular, trapezius muscles, and right triceps surae, which persisted in the final examination for the upper trapezius, SCM, pectoralis major and minor, and right triceps surae. However, the trigger points on the left levator scapulae and left trapezius were resolved, and the middle and lower trapezius showed bilateral hypotonicity in the final examination. The paravertebrals also showed improvement in tonicity and had a resolved trigger point on the left side.

In conclusion, while some muscular imbalances persisted, the targeted therapy seemed to have helped improve tonicity in some areas and resolve trigger points. However, further targeted therapy may still be necessary to fully address the remaining imbalances.

Neurological – sensations

Sensation appeared to slightly improve from feeling a significant difference between touch on the left and right leg to feeling a little less intense compared to the right side.

Fascia

Improvements in the condition of certain muscle groups' fascia mobility were observed. The fascia lata and ITB, which were initially found to be restricted, showed a noticeable improvement and were mildly restricted at the end of therapy. Similarly, the adductors, which were initially restricted bilaterally, had improved significantly, with the left side being mildly restricted and the right-side yielding. The left quadriceps femoris also showed improvement, going from restricted to mildly restricted. However, the pectoral muscles remained restricted and required further targeted therapy.

Movement pattern

During the third therapy unit, hip and shoulder ABD were examined. Hip ABD tended to FLX the hip and limit ROM. Shoulder ABD showed bilateral shoulder elevation at around 50º. Hip EXT was examined bilaterally in the fourth therapy unit once the patient could lie comfortably in prone. Hip EXT initiation showed that the ipsilateral synergistic erector spinae contracts earlier than the primary mover - gluteus maximus, altering the movement pattern on both sides and could stress the lumbar spine causing low back pain. Hip EXT was restricted on the left side (measuring only 10º).

By the fifteenth therapy unit, bilateral hip EXT was performed and showed muscle activation and range of motion (ROM) improvement. Both sides demonstrated better activation of the gluteus maximus and a ROM improvement to 15º and 20° (left and right, respectively) with no pain in movement. During hip ABD in right side lying, there was a significant reduction in hip FLX tendency, and the ROM improved to 35°. Bilateral shoulder ABD was tested, showing an improvement in shoulder elevation to approximately 65° (from 50°). The patient's head remained protracted forward, and the shoulders as well.

AROM

ROM was tested in therapy units one, seven and fifteen to monitor progress. In the first unit, some measurements were impossible due to pain or positioning after surgery. Measurements from the seventh therapy unit were performed when the patient's pain had subsided and they could transfer into different positions. The sixteenth therapy unit was the final examination to conclude the therapy. Throughout the therapy, there were several changes in the patient's ROM and in the end, AROM was painless.

Movement	**Left** (º)	**Right**	**Norm**
Hip FLX	From 25º to 100º	From 90º to 120º	120/135º
Hip EXT	From 10º to 15º	From 15º to 20º	10/30º
Hip ABD	From 20º to 35º	From 35º to 45º	30/50º
Hip ADD	From 10º to 20º	From 15º to 25º	10/30º
Knee FLX	x	From 110º to 125º	120/160º
Wrist plantarFLX	x	From 65º to 70º	80/85º

Table 25: AROM improvements

Transfers/ mobility

During the first therapy unit, all activities were performed while lying flat on the back due to pain and limited mobility. In the second therapy unit, the patient could perform exercises while lying on their side and sitting up without aid. During sitting, the patient was stable. However, he was slightly dizzy and sat with a hunched back. Transfer to standing was done with the help of a high walker and a physiotherapist. In the third therapy session, the first transfer to prone was attempted. It was primarily difficult due to a mental blockage. After proper education, the patient could transfer into prone with ease. The patient stood up using the high walker and had no additional assistance in the fourth therapy unit without being dizzy and with good balance. In the fifth therapy unit, transfer to prone and seated was done without any problems. It was the first time to stand up using a single crutch. Little assistance was required, but the patient was stable once standing. In the sixth therapy unit, the patient could transfer safely in all positions without any assistance, including standing up with one crutch, and could transfer into a wheelchair on the first attempt. Finally, by the sixteenth therapy unit, the patient continued progressing with the ease and smoothness of the transfers, with no dizziness and good balance.

Gait

Initially, the patient began taking steps in the third therapy unit using a high walker after achieving stability while standing. During these early steps, the patient tended to FLX at the left hip around 15^{o} and had small step-strides. However, the patient was able to take steps instead of hops and did not drag their foot. In the fourth therapy unit, the patient was able to walk about 10m in the high walker while focusing on maintaining an upright posture. By the fifth unit, the patient was able to walk 20m independently in the high walker with better stride length, and crutches were used for the first time to make use of the patient's upper body strength. 4m were reached on crutches, with the support of two physiotherapists. The patient was able to walk 4m on crutches with the support of two physiotherapists. Although relatively stable, the right knee FLX was present in the initial swing phase. The patient experienced some difficulty in keeping upright and tended to protrude their head forward.

The patient made quick progress on crutches by becoming more stable and was able to walk 10m and 20m in the sixth and seventh therapy units with the support of two physiotherapists, respectively. The focus was on maintaining good posture and gait

stereotypes. By the tenth therapy unit, the patient was able to use a wheelchair to get to the staircase and was able to take four steps up and down with the support of two physiotherapists, followed by 20m of walking on crutches with the support of one physiotherapist. The patient's left hip EXT during the gait had improved by this point.

By the eleventh therapy unit, the patient was able to take 11 steps up and down the staircase with the support of two physiotherapists but felt less confident when walking downstairs. The focus was on technique, and the patient went slower while being supported. By the end of the fifteenth therapy unit, the patient was able to walk up two flights of stairs with support from one physiotherapist, walk confidently with crutches, and significantly improve their left hip EXT during gait.

Overall, the patient’s gait has improved. There is no pain, and in general, it adheres to a typical pattern. The patient's gait stereotype has improved in both the high walker and on crutches, with the presence of heel strike during initial contact and all five toes in contact with the ground during loading response. While the knee tends to FLX more in crutches and is more EXT when in the high walker during mid- and terminal-stance, the patient's left hip still tends to hip FLX, especially in midstance. However, the patient is able to correct this when focusing on it, and there is good knee EXT at the start of the swing phase with no problem for hip FLX to propel forward. Overall, the patient's gait adheres to a typical pattern.

3.6.1 Summary of Therapy Effectiveness

Objectively the therapy sessions have effectively addressed the patient's pain, muscle strength, gait, movement patterns, anthropometrics, transfers/ mobility, and breathing pattern.

The patient's pain has significantly reduced, and he no longer requires medication for pain relief. His muscle strength has improved, as evidenced by the better results in the lower extremity muscle tests. The patient's gait has also improved, and he can walk independently using a high walker or crutches and use the stairs. Overall posture during the gait showed improvement, especially in staying more upright, and his left hip EXT during gait had significantly improved. However, the patient still holds his head and shoulder protracted forwards. There has been an improvement in the movement patterns of hip EXT, ABD, and shoulder ABD. In which the ROM and muscle activation improved. Anthropometric measurements showed a reduction in left thigh circumference. The patient's mobility has improved, as they can perform exercises while lying on their side, stand up independently using a crutch, and lie prone without any issues. AROM testing showed significant changes. For instance, the left and right hip FLX went from 25^{o} to 100^{o} and 90 to $120^{o,}$ respectively. Hip EXT, ABD, and ADD; right knee FLX and right wrist plantarFLX also showed increased ROM. Finally, the patient's breathing pattern has also improved slightly, with not using accessory muscles when breathing in an upright standing position.

Overall, the therapy sessions have effectively addressed the patient's various issues, and the patient has made significant progress.

3.6.2 Prognosis

The prognosis is positive regarding the patient's results and progress from the therapy sessions. Initially, the man did not have much hope after the surgery, but his brisk progress and want to get better as soon as possible helped him improve the session after the applied therapies. Although much progress has been made since the first therapy unit, the rehabilitation process has just begun, and the patient has a long journey ahead, including his prosthetic fitting and training.

With continued rehabilitation and a more positive mindset, the patient can be expected to improve his mobility and independence further.

3.7 Discussion

The primary goal of the therapy units was to aid the patient in regaining independence during the early rehabilitation phase following LLA and prepare them for the subsequent phase of prosthesis fitting and training. With the implementation of various interventions, including strengthening weak muscles, stretching tight muscles, practicing correct movement patterns, releasing tight fascia, and performing AROM exercises, the therapy units were able to achieve this objective. Jamieson, Murray, and Buis (2020) have highlighted the importance of a comprehensive approach to post-surgery rehabilitation, which includes strengthening exercises, gait training, and mobility training. Abou et al. (2022) emphasize the benefits of physical rehabilitation interventions, such as resistance and gait training and balance exercises, which lead to significant improvements in gait speed, balance, and physical function for individuals with LLA. It also states the importance of exercise interventions for older adults with LLA, as they are more likely to experience a decline in physical function and mobility compared to younger individuals with LLA.

Although the progress made by the patient has been commendable, it is still clear that there is a long way to go in achieving full independence. However, the results achieved so far are evidence that with consistent effort, it is possible to reach the desired outcome of complete independence. However, incorporating EBM techniques into the therapy plan during the early rehabilitation phase could have optimized the patient outcomes.

During the rehabilitation process, the management of PLP was not given much active attention or emphasis, despite the patient's complaints. As pointed out in studies by Herrador Colmenero et al. (2018) and Campo-Prieto and Rodriguez-Fuentes (2022), mirror therapy could have been employed to reduce the intensity and duration of PLP. MacLachlan, McDonald, and Waloch (2004) conducted a case study on a 59-year-old male with post-LLA and PLP that was characterized as shooting and stabbing pain on an 8/10 pain scale. The patient underwent mirror therapy for four weeks, consisting of 30-minute daily sessions. During the therapy, the patient was instructed to focus on the reflection in the mirror and imagine moving his phantom limb. At the end of the 4-week intervention, the patient reported a significant reduction in PLP intensity, with a reduction to a 2/10 pain scale rating. Additionally, the frequency of pain occurrence was reduced, and the duration of pain episodes was shorter.

The therapy plan had a minor flaw in not addressing the improvement of the residual limb sensation. There were various ways to accomplish this, such as tactile stimulation through tapping, massaging, or vibration (*Osborn, 2020*) or using Transcutaneous electrical nerve stimulation (TENS) to stimulate nerve endings and promote sensory feedback (*Osborn et al., 2018*). Additionally, mirror therapy could have helped promote sensory feedback and to help retrain the brain by providing visual feedback that can ‘’trick’’ the brain into perceiving movement and sensation in the residual limb (*Ramachandran, V. S., & Altschuler, E. L., 2009*). In the later phase, after the incision has healed, desensitization techniques could be implemented, gradually exposing the residual limb to different textures, temperatures, and pressures to reduce hypersensitivity at the site of the incision, preparing the patient for prosthetic training (*O’Keeffe and Rout., 2019*).

As the patient struggled with negative self-talk and mindset after the surgery, working with a therapist specializing in CBT could have been a valuable addition in helping the patient navigate and improve their psychological struggles during this phase (*Alavi, Molavi, and Molavi, 2017; Mayo et al., 2022*) as it would help remove mental blockages causing lower self-esteem and reduced confidence in his ability to recover and return to his daily activities. CBT could have facilitated a more positive and productive rehabilitation experience from the start.

Despite the patient's notable progress in exercises and gait, the implementation of NMES alongside exercise could have further enhanced motor function and strength by targeting weaker muscle groups. According to a study conducted by Talbot, Brede, and Metter (2017), combining NMES with exercise can result in increased muscle strength and improved functional performance for transfemoral amputees. The authors assert that NMES can expedite the activation of the quadriceps muscle during gait training, enhance muscle recruitment patterns, and promote overall muscle strength. Ultimately, these benefits of NMES can contribute to better gait symmetry and functional improvement in transfemoral amputee patients supporting that incorporating NMES into transfemoral amputee patient rehabilitation in conjunction with exercise and gait training may be a beneficial approach.

Therefore, incorporating these EBM techniques into the therapy plans could have enhanced the overall recovery process, helped prepare the patient for the next phase of recovery even more, and helped improve the efficacy and quality of rehabilitation interventions, leading to better patient outcomes.

3.8 Conclusion

In conclusion, the success of therapy techniques was evident in the progress made by a patient who had undergone the LLA. Using the knowledge gained from three years of study at the faculty, a therapy plan was developed that was effective in helping the patient improve his condition significantly after undergoing surgery and help overcome feelings of hopelessness, negative self-talk, and doubts.

Initially, he experienced intense pain, had limited ROM, and lacked confidence in his transfer ability, let alone standing up and walking. However, with time, his progress was remarkable. He went from learning to use crutches for the first time and struggling to navigate stairs to being able to walk with them comfortably, experiencing reduced pain, and feeling a sense of pride in his achievements. His positive attitude towards future sessions motivated him to push further and achieve more significant progress.

The structured, achievable goals and short- and long-term therapy plan contributed to the therapy techniques' success. In addition, this experience benefited the patient and myself, allowing me to work with a unique case of LLA.

The patient's subjective feedback about feeling more confident, ability to carry out daily tasks with ease, and willingness to pursue self-therapy exercises, complete rehabilitation, and obtain a prosthetic device is a positive indication. This determination will allow him to regain even more of his independence and return to his hobbies again.

This case study was an eye-opening experience. It was fascinating to witness the complex process of adapting to a new life after such a surgery. I was amazed at how quickly the body adapts to the situation it is in and how resilient humans can be in the face of adversity. It was a privilege to be part of the patient's rehabilitation journey, and I am grateful for the opportunity to work with such a dedicated team of healthcare professionals and be a part of the patient’s road to recovery. Overall, I thoroughly enjoyed my clinical work placement at Nemocnice na Homolce and the valuable lessons and knowledge that came with it.

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5. Annexes

5.1 List of Tables

Table 1: Sports and their specialized Prosthetics 15
Table 2: LLA prosthetic components 16
Table 3: LLA operation contraindications 20
Table 4: Examinations used 40
Table 5: Therapeutic Methods and Therapy aids used 40
Table 6: Basic patient information 41
Table 7: Initial kinesiological examination – Muscle strength Tests 43
Table 8: Initial kinesiological examination – Anthropometric Measurements 44
Table 9: Initial kinesiological examination – AROM goniometry measurements 44
Table 10: Initial kinesiological examination – Muscle tone palpation 45
Table 11: Initial kinesiological examination – Neurological – sensations 45
Table 12: Initial kinesiological examination – Fascia 46
Table 13: Additional data second therapy unit – Muscle tone palpation 47
Table 14: Additional data third therapy unit – Muscle tone palpation 48
Table 15: Additional AROM goniometry measurements 48
Table 16: Additional data fourth therapy unit – Muscle tone palpation 49
Table 17: Additional data fourth therapy unit – Fascia 49
Table 18: AROM goniometry measurements – Third therapy unit 61
Table 19: Final kinesiological examination – Muscle strength Tests 93
Table 20: Final kinesiological examination – Anthropometric Measurements 94
Table 21: Final kinesiological examination – AROM goniometry measurements 94
Table 22: Final kinesiological examination – Muscle tone palpation 95
Table 23: Final kinesiological examination – Fascia 95
Table 24: Final kinesiological examination – Gait examination 97
Table 25: AROM improvements 103

5.2 List of Images

Image 1: Illustration of different amputation levels 8

5.3 Model informed consent

UNIVERZITA KARLOVA V PRAZE
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

INFORMOVANÝ SOUHLAS

Vážená paní, vážený pane,

v souladu se Všeobecnou deklarací lidských práv, zákonem č. 101/2000 Sb., o ochraně osobních údajů a o změně některých zákonů, ve znění pozdějších předpisů, Helsinskou deklarací, přijatou 18. Světovým zdravotnickým shromážděním v roce 1964 ve znění pozdějších změn (Fortaleza, Brazílie, 2013) a dalšími obecně závaznými právními předpisy Vás žádám o souhlas s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie prováděné v rámci praxe na ……., kde Vás příslušně kvalifikovaná osoba seznámila s Vaším vyšetřením a následnou terapií. Výsledky Vašeho vyšetření a průběh Vaší terapie bude publikován v rámci bakalářské práce na UK FTVS, s názvem ……

Získané údaje, fotodokumentace, průběh a výsledky terapie budou uveřejněny v bakalářské práci v anonymizované podobě. Osobní data nebudou uvedena a budou uchována v anonymní podobě. V maximální možné míře zabezpečím, aby získaná data nebyla zneužita.

Jméno a příjmení řešitele ..... Podpis:.....

Jméno a příjmení osoby, která provedla poučení..... Podpis:.....

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že dobrovolně souhlasím s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie ve výše uvedené bakalářské práci, a že mi osoba, která provedla poučení, osobně vše podrobně vysvětlila, a že jsem měl(a) možnost si řádně a v dostatečném čase zvážit všechny relevantní informace, zeptat se na vše podstatné a že jsem dostal(a) jasné a srozumitelné odpovědi na své dotazy. Byl(a) jsem poučen(a) o právu odmítnout prezentování a uveřejnění výsledků vyšetření a průběhu terapie v bakalářské práci nebo svůj souhlas kdykoli odvolat bez represí, a to písemně zasláním Etické komisi UK FTVS, která bude následně informovat řešitele.

Místo, datum .....

Jméno a příjmení pacienta ..... Podpis pacienta: .....

5.4 Application for Approval UK FTVS Ethics Committee

UNIVERZITA KARLOVA V PRAZE
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

Application for Approval by UK FTVS Ethics Committee

of a research project, thesis, dissertation or seminar work involving human subjects

The title of a project: Case study of physiotherapy Early Phase Rehabilitation and Adaptation following Lower Limb Amputation

Project form: Bachelor Thesis

Period of realization of the project: January 2023 – February 2023
The research will be carried out in accordance with the valid epidemiological measures of the Ministry of Health of the Czech Republic

Applicant: Lucie Fiala

Main researcher: Lucie Fiala

Co-researcher(s):

Supervisor (in case of student's work): Mgr. Michaela Stupková

Financial support:

Project description: I will be writing my bachelor thesis and working with a lower amputee patient at Nemocnice na Homolce, who has been amputated acutely after being hospitalized for 2 months with the attempt to save his leg. The case study will include examination such as goniometry, anthropometrics and posture amongst other examinations. The kinesiological examination will be followed by therapy and treatment in which the aims are to strength the lower limb, teach the patient to be able to independently transfer himself, lengthen shortened muscles, and to learn how to use a wheel chair and walk using crutches.

Characteristics of participants in research: One patient is involved, a male who is 68 years old and was assigned to me by my supervisor at Nemocnice na Homolce. Patients with acute (especially infectious) diseases do not participate in therapy.

Ensuring safety within the research: Non-invasive methods will be used and the patient will not be at risk as all techniques and methods used will not harm the patients' health. My supervisor at the hospital will be present to control my techniques and therapy at Nemocnice na Homolce. Risks of therapy and methods will not be higher than the commonly anticipated risks for this type of therapy.

Ethical aspects of the research: Data will be collected in line with the rules given by European Union no. 2016/679 and the Czech Act no. 110/2019 Coll. – on personal data processing.
The collected data will be anonymized within one week after the end of working with the patient. I understand that anonymization means that the text does not use any item of information or combination of Items that could lead to the identification of a person. I will be careful not to enable recognition of a person in the text of the thesis, especially within the anamnesis. After the text has been anonymized, any personal data still kept elsewhere will be deleted.
All collected data will be safely stored on a PC safeguarded by a keyword in a locked room, any data in paper form will be kept safely under lock and key in a locked room. The data will be processed, safely retained and published in an anonymous way in the bachelor thesis.

Photographs: Photographs of the participant will be anonymized within one week after being taken by blurring the face, parts of the body or any characteristics that could lead to identification of the person. After anonymization any non-anonymized photographs will be deleted. The non-anonymized photographs will be accessed only by the main researcher and supervisor.

No audio recordings or video recordings will be taken during the research.

I shall ensure to the maximum extent possible that the research data will not be misused.

Informed Consent: attached

It is a duty of **all participants of the research team** to protect life, health, dignity, integrity, the right to self-determination, privacy and protection of the personal data of all research subjects, and to undertake all possible precautions.

UNIVERZITA KARLOVA V PRAZE
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

Responsibility for the protection of all research subjects lies on the researcher(s) and not on the research subjects themselves, even if they gave their consent to participation in the research. All participants of the research team must take into consideration ethical, legal and regulative norms and standards of research involving human subjects applicable not only in the Czech Republic but also internationally.

I confirm that this project description corresponds to the plan of the project and in case of any change, especially of the methods used in the project, I will inform the UK FTVS Ethics Committee, which may require a re-submission of the application form.

In Prague, 17.01.2023 Applicant's signature: Lucie Fialová

Approval of UK FTVS Ethics Committee

The Committee: Chair: Doc. PhDr. Irena Parry Martínková, Ph.D.
Members: Prof. PhDr. Pavel Slepička, DrSc. Prof. MUDr. Jan Heller, CSc.
PhDr. Pavel Hráský, Ph.D. Mgr. Eva Prokešová, Ph.D.
Mgr. Tomáš Ruda, Ph.D. MUDr. Simona Majorová

The research project was approved by UK FTVS Ethics Committee under the registration number: 105/2023
Date of approval: 17. 1. 2023

UK FTVS Ethics Committee reviewed the submitted research project and **found no contradictions** with valid principles, regulations and international guidelines for carrying out research involving human subjects.

The applicant has met the necessary requirements for receiving approval of UK FTVS Ethics Committee.

UNIVERZITA KARLOVA
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52, Praha 6
– 20 –
Stamp of UK FTVS

Signature of the Chair of
UK FTVS Ethics Committee