CHARLES UNIVERSITY

FACULTY OF PHYSICAL EDUCATION AND SPORT

Department of Physiotherapy

Rehabilitation after Total Hip Replacement

Bachelor Thesis

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Declaration

I hereby declare that I am the sole composer and author of this bachelor's thesis and that this is entirely the result of my own work, except where specifies otherwise by citation or acknowledgement. I further declare that this thesis has not been submitted for any other degree or qualification.

In Prague: _____ _____

Author's signature

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Abstract

Thesis title: Rehabilitation after Total Hip Replacement.

Aim: To examine and better understand the human hip joint, coxarthrosis, total hip replacement and the subsequent rehabilitation care.

This thesis consists of a case study (special part) and a theoretical part. The subject of the case study is a 71-year-old male patient who underwent a total hip replacement due to coxarthrosis and received physiotherapy after the surgery. The case study is composed of the anamnesis of the patient, and the details of the initial kinesiological examination, final kinesiological examination, and therapeutic procedures the patient underwent. The theoretical part contains basic theoretical knowledge, such as the anatomy and kinesiology of hip joint, clinical details of coxarthrosis, basics of total hip replacement, as well as some typical components of total hip replacement rehabilitation protocols.

The patient showed some improvements after the therapy program. The aim of this thesis has been achieved.

I began writing this thesis after my completion of an 80-hour clinical placement at the Revmatologický ústav (Institute of Rheumatology) in Prague, Czech Republic, during the period 4th February 2019 to 15th February 2019.

Keywords: coxarthrosis, hip osteoarthritis, hip replacement, hip endoprosthesis, physiotherapy, rehabilitation

Abstrakt

Název práce: Rehabilitace po totální endoprotéze kyčelního kloubu

Cíl: Zkoumání a lepší pochopení kyčelního kloubu člověka, koxartrózy, totální endoprotézy kyčelního kloubu a následné rehabilitační péče.

Tato práce se skládá z kazuistiky - speciální části a teoretické části. Předmětem kazuistiky byl 71 letý pacient, který z důvodu koxartrózy podstoupil totální endoprotézu kyčelního kloubu a po operaci byl v péči fyzioterapeutů. Kazuistika se skládá z anamnézy pacienta, vstupního kineziologického rozboru, konečného kineziologického rozboru a terapeutických postupů, které pacient podstoupil. Teoretická část obsahuje nezbytné teoretické znalosti jako jsou anatomie a kineziologie kyčelního kloubu, klinické detaily koxartrózy, základy totální endoprotézy kyčelního kloubu a také typické součásti rehabilitačních programů po totální endoprotéze kyčelního kloubu.

Pacient po terapeutickém programu vykazoval zlepšování stavu. Cíl této práce byl dosažen.

Tuto práci jsem začal psát po dokončení 80 hodinové klinické praxe na Revmatologickém ústavu v Praze v České republice v období od 4. února 2019 do 15. února 2019.

Klíčová slova: koxartróza, osteoartróza kyčelního kloubu, endoprotéza kyčelního kloubu, fyzioterapie, rehabilitace

List of abbreviations and symbols

ADL = Activity of daily living

AROM = Active range of motion

ASIS = Anterior superior iliac spine

BMI = Body mass index

COM = Center of mass

COX-2 = Cyclo-oxygenase 2

CT = Computed tomography

DIP = Distal interphalangeal

DVT = Deep vein thrombosis

ESR = Erythrocyte sedimentation rate

F90 = In 90-degree flexion

FAI = Femoroacetabular impingement

GRF = Ground reaction force

HATL = Head, arms, trunk, and the opposite lower extremity

ICD-10 = International Statistical Classification of Diseases and Related Health Problems 10th edition

I/T = Intensity-time

JAMA = Journal of American Medical Association

JRF = Joint reaction force

L1/2/3/4/5 = 1st/2nd/3rd/4th/5th lumbar nerve

LE = Lower extremity

MTP = Metatarsophalangeal

NICE = National Institute for Health and Care Excellence

NSAID = Non-steroidal anti-inflammatory drug

OA = Osteoarthritis

PIP = Proximal interphalangeal

PIR = Post-isometric relaxation

PMMA = Polymethylmethacrylate

PNF = Proprioceptive neuromuscular facilitation

PROM = Passive range of motion

PSIS = Posterior superior iliac spine

RACGP = Royal Australian College of General Practitioners

RI = Reciprocal inhibition

ROM = Range of motion

S1/2 = 1st/2nd sacral nerve

S.F.T.R = Sagittal-Frontal-Transverse-Rotation

STP = Status post

STT = Soft tissue techniques

TEP = Total endoprosthesis

THA = Total hip arthroplasty

THR = Total hip replacement

UNIFY ČR = Unie fyzioterapeutů české republiky

VAS = Visual analogue scale

WHO = World Health Organization

xxx = Not tested

CONTENTS

1 INTRODUCTION

This thesis aims to examine and better understand the human hip joint, coxarthrosis, total hip replacement and the subsequent rehabilitation care. It is composed of 2 main parts, the General Part, and the Special Part.

The General Part aims to present the theoretical background of total hip replacement and coxarthrosis. This part contains information such as the anatomical description of the hip joint and its kinesiology, information concerning hip osteoarthritis, surgical specifications of a total hip replacement, and some typical parts of rehabilitation protocols for patients before and after a total hip replacement.

The Special Part contains an elaborated case study on the post-operative, in-patient rehabilitation care received by a patient who underwent a total hip replacement due to coxarthrosis. The case study includes a comprehensive anamnesis of the patient and an initial kinesiological analysis which I performed on the patient. Some short-term goals and long-term goals of rehabilitation were established after the initial kinesiological analysis. Therapy progress has been documented as part of the case study. After all the therapy sessions, a final kinesiological examination was performed in order to evaluate the effects of the used therapy on the patient.

The case study is based on the clinical placement which I undertook at the Revmatologický ústav (Institute of Rheumatology) in Prague, Czech Republic, during the period 4th February 2019 to 15th February 2019.

All the physiotherapy procedures I performed during the placement were what I have learnt during my bachelor's studies in physiotherapy at the Faculty of Physical Education and Sport of Charles University, Prague, Czech Republic. No invasive methods were employed.

2 GENERAL PART

2.1 The hip joint

The hip joint is the articulation between the hemispherical head of femur and the cup-shaped acetabulum of the hip bone (46). It is a strong, stable multi-axial ball-and-socket type of synovial joint. The hip joint is designed for stability over a wide range of movement. It is the most movable joint in the body after the glenohumeral joint. The weight of the upper body is transferred through the hip bones to the femurs during standing. The hip joints are enclosed by strong capsules and the articular surfaces are covered with hyaline cartilage (26).

2.1.1 Articular surfaces of the hip joint

The hip joint is the articulation between the hemispherical head of femur and the cup-shaped acetabulum of the hip bone (46).

The acetabulum is a hemispherical cavity on the outer surface of the hip bone, which is formed by the fusion of 3 bony structures: The ilium, ischium, and the pubis. The anterior one-fifth of the acetabulum is formed by the pubis, the superior posterior two-fifths by the body of ilium, and the inferior two-fifths by the ischium (35). The articular surface of the acetabulum is horseshoe-shaped and is deficient inferiorly at the acetabular notch (46). The prominent acetabulum rim consists of a semi-lunar articular part covered with articular cartilage and the lunate surface of acetabulum. The acetabular rim and lunate surface forms approximately 3 quarters of a circle superior to the acetabular notch (26).

The cavity of the acetabulum is deepened by the presence of a fibrocartilaginous rim called the acetabular labrum (46). The lip-shaped acetabular labrum attaches to the

margin of the acetabulum, increasing the acetabular articular surface by nearly 10% (26). The labrum bridges across the acetabular notch and is here called the transverse acetabular ligament (46).

The femoral head forms approximately two thirds of a sphere. It is slightly compressed in an anteroposterior direction. The whole femoral head is covered with articular cartilage, with the exception of a small area superolaterally adjacent to the neck and at the fovea capitis of the femur (35). The hyaline articular cartilage is the thickest over weight-bearing areas (26). Anteriorly, the cartilage extends onto the femoral neck for a short distance. Both the acetabulum and the head of femur are composed of cancellous bone covered by a thin layer of compact bone (35).

The 2 articular surfaces of the hip joint are reciprocally curved, but the hip joint consists of 2 incongruent shapes.

The articular surfaces of the acetabulum and the head of femur are the most congruent when the axis of the acetabulum and the axis of the head and neck of femur are aligned. Such an alignment is achieved when hip flexion is at 90 degrees, abduction at 5 degrees, and external rotation at 10 degrees, which corresponds to a quadrupedal position (26).

2.1.2 Joint capsule of the hip joint

The hip joint is enclosed by a strong joint capsule, composed of a loose external fibrous layer and an internal synovial membrane. Proximally, the fibrous layer attaches to the acetabulum, just peripheral to the acetabular rim to which the labrum is attached (26). Opposite the acetabular notch, the capsule attaches to the transverse ligament. On the femur, the capsule attaches anteriorly to the intertrochanteric line and to the junction of the neck with the trochanters. Posteriorly, the capsule has an arched free border and covers the medial two-thirds of the neck only, approximately as far laterally as the groove formed by the tendon of obturator externus (35).

Most fibers of the fibrous layer of the capsule take a spiral course from the hip bone to the intertrochanteric line of the femur, but some deeper fibers pass circularly

around the capsule and have no bony attachments, constituting the orbicular zone (26). At the zona orbicularis, the deep fibers are reinforced by the deep part of ischiofemoral ligament (35). Thick parts of the fibrous layer form the ligaments of the hip joint, which run in a spirally from the pelvis to the femur (26).

2.1.3 Ligaments of the hip joint

The iliofemoral ligament is a strong, Y-shaped ligament which reinforces and strengthens the hip joint anteriorly and superiorly. The proximal part of the ligament attaches to the lower part of the anterior inferior iliac spine and adjacent part of the acetabular rim. The distal part of the ligament attaches to the intertrochanteric line of femur. The iliofemoral ligament prevents hyperextension of the hip joint during standing by screwing the head of femur into the acetabulum (26, 35).

The pubofemoral ligament is a triangular ligament (46) which strengthens the inferior and anterior aspects of the joint capsule. It passes from the iliopubic eminence and superior pubic ramus to the lower part of the intertrochanteric line, blending with the inferior band of the iliofemoral ligament (35) and the medial part according to Moore et al. (26). This ligament prevents overabduction of the hip joint (26).

The ischiofemoral ligament is weaker (26) and less well-defined (35) than either the iliofemoral or pubofemoral ligament. It spirals superiorly and laterally to the neck of femur, medial to the base of the greater trochanter (26). Some of the deeper fibers are continuous with the zona orbicularis (35).

The transverse ligament of acetabulum completes the inferior deficiency in the acetabular rim, creating a foramen with the acetabular notch through which the vessels and nerves may enter the joint (35).

The ligament of the head of femur (also known as the ligamentum teres) is primarily a synovial fold conducting a blood vessel. It is weak and not crucial in strengthening the hip joint. It is attached to the adjacent margins of the acetabular notch and the lower border of the transverse acetabular ligament, narrowing as it passes to insert

into the fovea capitis of femur. The function of this ligament in adults is uncertain. The small vessel it conducts in early childhood becomes obliterated in late childhood (26, 35).

2.1.4 Muscles around the hip joint

This part contains information concerning the anatomical movements of the hip joints according to Snell (46) and the anatomical description of the main muscles involved in each of the movements written by Hansen (14). The spinal cord segmental innervation is indicated in parentheses. Muscles for hip circumduction is not included in this section as circumduction is a combination of the motions described below (46):

2.1.4.1 Flexion

Flexion is performed by the *iliopsoas, rectus femoris, sartorius*, and the *adductor* muscles.

- *Iliacus*

  Proximal attachment: Iliac crest, iliac fossa, ala of sacrum, and anterior sacroiliac ligaments

  Distal attachment: Tendon of psoas major, lesser trochanter, and femur

  Innervation: Femoral nerve (L2-L4)

  Main action(s): Acts jointly with psoas major in flexing thigh at hip joint and in stabilizing this joint

■ *Psoas major*

Proximal attachment: Sides of T12-L5 vertebrae and discs between them; transverse processes of all lumbar vertebrae

Distal attachment: Lesser trochanter of femur

Innervation: Anterior rami of lumber nerves (L1-L3)

Main action(s): Acts jointly with iliacus in flexing thigh at hip joint and in stabilizing this joint

■ *Rectus femoris*

Proximal attachment: Anterior inferior iliac spine and ilium superior to acetabulum

Distal attachment: Base of patella and by patellar ligament to tibial tuberosity

Innervation: Femoral nerve (L2-L4)

Main action(s): Extend leg at knee joint; also steadies hip joint and help iliopsoas to flex thigh at hip

■ *Sartorius*

Proximal attachment: Anterior superior iliac spine and superior part of notch inferior to it

Distal attachment: Superior part of medial surface of tibia

Innervation: Femoral nerve (L2-L3)

Main action(s): Flexes, abducts, and laterally rotates thigh at hip joint; flexes knee joint

■ *Adductor magnus*

Proximal attachment: Inferior ramus of pubis, ramus of ischium, and ischial tuberosity

Distal attachment: Adductor part: gluteal tuberosity, linea aspera, medial supracondylar line. Hamstring part: adductor tubercle of femur

Innervation: Adductor part: obturator nerve. Hamstring part: tibial part of sciatic nerve

Main action(s): Adducts thigh at hip. Adductor part: also flexes thigh at hip. Hamstrings part: extends thigh

■ *Adductor brevis*

Proximal attachment: Body and inferior ramus of pubis

Distal attachment: Pectineal line and proximal part of linea aspera of femur

Innervation: Obturator nerve (L2-L4)

Main action(s): Adducts thigh at hip and, to some extent, flexes it

2.1.4.2 Extension

Extension is performed by *gluteus maximus* and the *hamstring muscles*.

■ *Gluteus maximus*

Proximal attachment: Ilium posterior to posterior gluteal line; posterior surface of sacrum and coccyx, and sacrotuberous ligament

Distal attachment: Most fibers end in iliotibial tract that inserts into lateral condyle of tibia; some fibers insert on gluteal tuberosity

Innervation: Inferior gluteal nerve (L5-S2)

Main action(s): Extends flexed thigh at the hip and assists in its lateral rotation; abducts and assists in raising trunk from flexion position

■ *Biceps femoris*

Proximal attachment: Long head: ischial tuberosity. Short head: linea aspera and lateral supracondylar line of femur

Distal attachment: Lateral side of head of fibula; tendon at this site split by fibular collateral ligament of knee

Innervation: Long head: tibial division of sciatic nerve (L5-S2). Short head: common fibular division of sciatic nerve (L5-S2)

Main action(s): Flexes leg at knee and rotates it laterally; extends thigh at hip (e.g., when starting to walk)

■ *Semimembranosus*

Proximal attachment: Ischial tuberosity

Distal attachment: Posterior part of medial condyle of tibia

Innervation: Tibial division of sciatic nerve (L5-S2)

Main action(s): Extends thigh at hip; flexes leg at knee and rotates it medially; with flexed hip and knee, extends trunk

■ *Semitendinosus*

Proximal attachment: Ischial tuberosity

Distal attachment: Medial surface of superior part of tibia

Innervation: Tibial division of sciatic nerve (L5-S2)

Main action(s): Extends thigh at hip; flexes leg at knee and rotates it medially; with flexed hip and knee, extends trunk

2.1.4.3 Abduction

Abduction is performed by *gluteus medius and minimus*, assisted by *sartorius*, *tensor fasciae latae*, and *piriformis*.

- *Gluteus medius*

Proximal attachment: Lateral surface of ilium

Distal attachment: Lateral surface of greater trochanter of femur

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts and medially rotates thigh at hip; steadies pelvis on limb when opposite limb is raised

- *Gluteus minimus*

Proximal attachment: Lateral surface of ilium

Distal attachment: Anterior surface of greater trochanter of femur

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts and medially rotates thigh at hip; steadies pelvis on limb when opposite limb is raised

- *Sartorius*

Proximal attachment: Anterior superior iliac spine and superior part of notch inferior to it

Distal attachment: Superior part of medial surface of tibia

Innervation: Femoral nerve (L2-L3)

Main action(s): Flexes, abducts, and laterally rotates thigh at hip joint; flexes knee joint

- *Tensor fasciae latae*

Proximal attachment: Anterior superior iliac spine and anterior iliac crest

Distal attachment: Iliotibial tract that attaches to lateral condyle of tibia

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts, medially rotates, and flexes thigh at hip; helps to keep knee extended

- *Piriformis*

Proximal attachment: Anterior surface of sacrum and sacrotuberous ligament

Distal attachment: Superior border of greater trochanter of femur

Innervation: Branches of anterior rami (L5-S2)

Main action(s): Laterally rotates extended thigh at hip and abducts flexed thigh at hip; steadies femoral head in acetabulum

2.1.4.4 Adduction

Adduction is performed by the *adductor longus and brevis* and the adductor fibers of *adductor magnus*. These muscles are assisted by the *pectineus* and the *gracilis*.

- *Adductor longus*

Proximal attachment: Body and inferior pubic crest

Distal attachment: Middle third of linea aspera of femur

Innervation: Obturator nerve (L2-L4)

Main action(s): Adducts thigh at hip

■ *Adductor brevis*

Proximal attachment: Body and inferior ramus of pubis

Distal attachment: Pectineal line and proximal part of linea aspera of femur

Innervation: Obturator nerve (L2-L4)

Main action(s): Adducts thigh at hip and, to some extent, flexes it

■ *Adductor magnus*

Proximal attachment: Inferior ramus of pubis, ramus of ischium, and ischial tuberosity

Distal attachment: Adductor part: gluteal tuberosity, linea aspera, medial supracondylar line. Hamstring part: adductor tubercle of femur

Innervation: Adductor part: obturator nerve. Hamstring part: tibial part of sciatic nerve

Main action(s): Adducts thigh at hip. Adductor part: also flexes thigh at hip. Hamstrings part: extends thigh

■ *Pectineus*

Proximal attachment: Superior ramus of pubis

Distal attachment: Pectineal line of femur, just inferior to the lesser trochanter

Innervation: Femoral nerve; may receive a branch from obturator nerve

Main action(s): Adducts and flexes thigh at hip

- *Pectineus*

Proximal attachment: Body and inferior ramus of pubis

Distal attachment: Superior part of medial surface of tibia

Innervation: Obturator nerve (L2-L3)

Main action(s): Adducts thigh at hip; flexes leg at knee and helps to rotate it medially

2.1.4.5 Lateral rotation

Lateral rotation is performed by the *piriformis*, *obturator internus and externus*, *superior and inferior gemelli*, and *quadratus femoris*, assisted by the *gluteus maximus*.

- *Piriformis*

Proximal attachment: Anterior surface of sacrum and sacrotuberous ligament

Distal attachment: Superior border of greater trochanter of femur

Innervation: Branches of anterior rami (L5-S2)

Main action(s): Laterally rotates extended thigh at hip and abducts flexed thigh at hip; steadies femoral head in acetabulum

- *Obturator internus*

Proximal attachment: Pelvic surface of obturator membrane and surrounding bones

Distal attachment: Medial surface of greater trochanter of femur

Innervation: Nerve to obturator internus (L5-S2)

Main action(s): Laterally rotates extended thigh at hip and abducts flexed thigh at hip; steadies femoral head in acetabulum

■ *Obturator externus*

Proximal attachment: Margins of obturator foramen and obturator membrane

Distal attachment: Trochanteric fossa of femur

Innervation: Obturator nerve (L3-L4)

Main action(s): Rotates thigh laterally at hip; steadies femoral head in acetabulum

■ *Superior gemellus*

Proximal attachment: Ischial spine

Distal attachment: Medial surface of greater trochanter of femur

Innervation: Nerve to obturator internus (L5-S2)

Main action(s): Laterally rotate extended thigh at the hip and abducts flexed thigh at the hip; steady femoral head in acetabulum

■ *Inferior gemellus*

Proximal attachment: Ischial tuberosity

Distal attachment: Medial surface of greater trochanter of femur

Innervation: Nerve to quadratus femoris (L4-S1)

Main action(s): Laterally rotate extended thigh at the hip and abducts flexed thigh at the hip; steady femoral head in acetabulum

■ *Quadratus femoris*

Proximal attachment: Lateral border of ischial tuberosity

Distal attachment: Quadrate tubercle on intertrochanteric crest of femur

Innervation: Nerve to quadratus femoris (L4-S1)

Main action(s): Laterally rotates thigh at hip

- *Gluteus maximus*

Proximal attachment: Ilium posterior to posterior gluteal line; posterior surface of sacrum and coccyx, and sacrotuberous ligament

Distal attachment: Most fibers end in iliotibial tract that inserts into lateral condyle of tibia; some fibers insert on gluteal tuberosity

Innervation: Inferior gluteal nerve (L5-S2)

Main action(s): Extends flexed thigh at the hip and assists in its lateral rotation; abducts and assists in raising trunk from flexion position

2.1.4.6 Medial rotation

Medial rotation is performed by the anterior fibers of the gluteus medius and gluteus minimus and the tensor fasciae latae.

- *Gluteus medius*

Proximal attachment: Lateral surface of ilium

Distal attachment: Lateral surface of greater trochanter of femur

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts and medially rotates thigh at hip; steadies pelvis on limb when opposite limb is raised

- *Gluteus minimus*

Proximal attachment: Lateral surface of ilium

Distal attachment: Anterior surface of greater trochanter of femur

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts and medially rotates thigh at hip; steadies pelvis on limb when opposite limb is raised

- *Tensor fasciae latae*

Proximal attachment: Anterior superior iliac spine and anterior iliac crest

Distal attachment: Iliotibial tract that attaches to lateral condyle of tibia

Innervation: Superior gluteal nerve (L4-S1)

Main action(s): Abducts, medially rotates, and flexes thigh at hip; helps to keep knee extended

2.1.5 Nerve supply to the hip joint

In 1863, Hilton found that "the same trunk of nerve which supplies the muscles, supplies the joints which move those muscles and the skin over the lengthened insertion in the fascia." Thus, a knowledge of the innervation of the muscles across the hip joint and the way they act on the joint allow one to deduce the innervation of the hip joint.

The hip joint is mainly innervated by branches of the femoral and obturator nerves from the lumbar plexus, as well as the superior gluteal nerve and the nerve to quadratus femoris from the sacral plexus (35).

According to Moore et al. (26):

The flexors which pass through the anterior aspect of the hip joint are mainly innervated by the femoral nerve. It directly, and via some branch to the pectineus and rectus femoris, innervates the anterior aspect of the hip joint.

The lateral rotators pass through the inferior and posterior aspects of the hip joint. The inferior portion of the joint is innervated by the obturator nerve directly and via some branches to the obturator externus, while the posterior aspect is innervated by the nerve to quadratus femoris.

The superior gluteal nerve, which innervates the abductors passing superiorly to the hip joint, also innervates the superior aspect of the hip joint.

2.1.6 Blood supply to the hip joint

The hip joint is supplied with blood from the medial and lateral circumflex femoral arteries, the obturator artery, and the superior and inferior gluteal arteries. They form a periarticular anastomosis around the joint (35).

The medial circumflex femoral artery usually arises from the deep artery of the thigh and travels inferiorly to the iliopsoas tendon. Its branches supply the head and neck of femur. The lateral circumflex femoral artery usually arises from the deep artery of the thigh as well (26).

There is always a small artery derived from the obturator artery lying inside the ligament of the head of femur. The most significant volume of blood supplies to the hip joint via the periarticular arterial anastomosis. The proper development of the periarticular anastomosis is crucial for the supply of nutrients to the bone, especially for the capital femoral epiphysis until the completion of ossification, both in the process of the development of the epiphysis and after a femoral fracture (35).

2.2 Osteokinematics between femur and pelvis

The hip joint has a wide range of movements, including flexion-extension around a transverse axis on the sagittal plane, abduction-adduction around a sagittal axis on the frontal plane, and lateral-medial rotation around a vertical axis. Circumduction is also permitted. The 3 axes intersect at the center of the head of femur (35).

2.2.1 Movements of femur of the sagittal plane

Hip flexion generally has a bigger range when it is done passively. The range of motion also depends on the position of the knee joint. Active hip flexion with the knee flexed has an ROM which can be approximately 30 degrees greater than that with the knee extended. The range of passive hip flexion always exceed 120 degrees but the flexed position of the knee joint still plays a role in increasing the range of hip flexion by relaxing the hamstrings (19).

When both hip joints are in passive flexion with the knees flexed, the range of hip flexion is greatly increased by the posterior tilt of the pelvis following the concurrent lumbar hyperkyphosis. This allows the thighs to come into contact with the chest (19).

During full hip flexion, the 3 primary capsular ligaments are loosened, but the inferior aspect of the capsule and muscles such as the gluteus maximus are stretched. Considerable variability in the range hip flexion can be expected as it highly depends on the flexibility of the hamstrings, which also has a high variability (29).

The range of active hip extension the knee extended is around 10 degrees greater than the range with the knee flexed. This happens as the result of the hamstrings utilizing most of the contraction to flex the knee and losing some efficiency as hip extensors (19). Extension beyond 30 degrees is normally impossible (35). The range of hip extension is greatly increased by an anterior tilt of the pelvis which can be induced by lumbar hyperlordosis. The same motion, however, can be limited by the anterior aspect of the hip joint capsule, the strong hip flexors, and the iliofemoral ligament (13). Full hip extension increases the passive tension in the aforementioned structures. With the knee flexed during hip extension, the passive tension in the rectus femoris, a muscle which spans

across the hip and the knee joints, reduces hip extension to approximately the neutral position (29).

2.2.2 Movements of the femur on the frontal plane

The range of hip abduction is approximately 30 to 45 degrees (35, 19, 13, 29).

Kapandji (19) pointed out that, theoretically, it is completely possible to abduct one hip only. However, in practice, abduction of the other hip would occur simultaneously. This becomes more pronounced when the hip abduction exceeds 30 degrees and the lateral tilt of the pelvis is observable.

Hip abduction is ultimately terminated upon the impact of the femoral neck on the acetabular margin (19). But before the impact, the motion is already limited mainly by the tension in the adductor muscles and the pubofemoral ligament (29). The range of hip abduction is approximately 30 to 45 degrees (13), and is the greatest when the hip is in partial flexion (35).

Hip adduction ranges from 15 to 30 degrees beyond the anatomical position (13) and is easier with the hip flexed (35). Full hip adduction is limited by tension in the abductor muscles, iliotibial tract, the superior fibers of the ischiofemoral ligament (29), and the lateral part of the iliofemoral ligament (35).

2.2.3 Movements of the femur on the transverse plane

The hip joint is able to laterally rotate through 30 degrees to 50 degrees (13), during which the shaft of femur shifts posteriorly around the mechanical axis when the hip is extended, causing the toes to point away from the midline of the body. With the hip extended, external rotation can be limited by the tension in the lateral fasciculus of the iliofemoral ligament and the internal rotator muscles. (29). When the hip and the knee are

in 90-degree flexion, the iliofemoral and pubofemoral ligaments are relaxed. This contributes to a greater range of lateral rotation (19).

The hip joint is also able to medially rotate through 30 degrees to 50 degrees (13), during which the shaft of femur moves anteriorly when the hip is extended, so that the toes are pointing towards the midline of the body. With the hip extended, internal rotation can be limited by the tension in the ischiofemoral ligament and the external rotator muscles (35). The range of internal rotation can also be increased with hip flexion (13). However, compared to lateral rotation, medial rotation is not as free, and the movement is not as powerful (35).

Medial rotation of the hip joints together with an in-toeing gait and pes planovalgus is a typical phenomenon in children. It is caused by an increased angle of anteversion of the neck of femur which leads to a limited range of lateral rotation. Normally, as children grow, the angle of anteversion decreases, the phenomenon would thus disappear. The wide angle of anteversion and defects, however, may remain when children adopt an unfavorable sitting position for an extended period of time (19).

2.3 Kinetics of the hip joint

2.3.1 Kinetics of single leg stance

In order to keep something in its upright position, a vertical line passing through the center of mass (COM) of the object must also pass through its base of support. During single leg stance, it is necessary for the weight of the head, arms, trunk, and the opposite lower extremity (HATL) over the stance limb to achieve a balance. For a human to keep his upright posture, the COM of HATL as a unit must in a vertical alignment with the stance foot. To reach this vertical alignment, the person would normally shift his pelvis laterally towards the stance to keep the COM vertically over the base of support. This puts the hip joint of the stance leg in adduction, and the weight of HATL creates an adduction moment on the stance hip, which ultimately causes an increase in the tendency of the pelvis dropping on the non-stance side (32).

At the same time, a ground reaction force (GRF) which is exerted vertically from the ground through the foot creates an adduction moment on the hip. This moment causes an increase in the tendency for the whole lower limb to rotate medially. The abductor muscles attached to the pelvis or the femur aid in counteracting the adduction moment. These abductor muscles pull with a force which is about 2 times the body weight to support the weight of HATL during single leg stance (32). The joint reaction force (JRF), the resultant compressive force at the femoroacetabular articulation (15), is around 2.5 times the body weight on the femoral head (32).

2.3.2 Kinetics of single leg stance with a cane

Using a cane significantly reduces the forces acting on the hip joint (15). When a person is standing with the support of a cane in a hand, he is still required to stand with the center of mass in a vertical alignment with the base of support. With a cane in the hand on the non-stance side, a person should be more able to maintain an upright posture with the COM kept over the enlarged base of support. The stance hip would be aligned

more directly over the stance foot, and the moment arm of the GRF would be shorter, compared to when standing without a cane (32). The moments generated by the cane support and the pull of the abductor muscles produce a moment with the same magnitude as but opposite to that generated by the effective body weight (15), and the use of a cane in the hand on the non-stance side reduces the force needed from the abductor muscles to around 50% of body weight (32). When approximately 15% of the body weight is applied to the cane, the joint reaction forces can be reduced by 50% (15). Nonetheless, according to Knudson (21), for patients after hip replacement surgery, holding a cane in the hand on the affected/non-stance side would not reduce the gravitational torque of the upper body about the stance hip. Therefore, the reduction of pain around the hip implant in this position would be minimal.

When the cane is in the hand on the stance side, the base of support would shift more laterally towards the stance side and would become further away from the hip joint than with no cane. This causes the person to lean even more laterally in order to maintain the vertical alignment in which the COM is still over the base of support. The trunk lean may reduce the weight of HATL effects on the adductor moment and may reduce the need of pull of the abductor muscles. However, this requires more muscle activities in the other parts of the body and it may lead to an increase in the load on the neighboring joints such as the knee joints and the lumbar spine joints (32).

According to Knudson (21), in patients after hip replacement surgery, holding a cane in the hand on the affected/non-stance side would not reduce the gravitational torque of the upper body about the stance hip. Therefore, the reduction of pain around the hip implant in this position would be minimal.

2.4 Osteoarthritis of the hip joint

This chapter aims to deliver a review on osteoarthritis (OA) of the hip joint, which is also known as “coxarthrosis”. Coxarthrosis is discussed with the exclusion of polyarthritis due to the fact that it was the end-stage osteoarthritis of the hip joint which directly necessitated a total hip replacement for the patient involved in the case study presented in the section “3 SPECIAL PART” of this thesis.

2.4.1 Epidemiology

A systematic review of the prevalence of radiological primary radiographic primary hip osteoarthritis was conducted by Dagenais et al. (9). The studies reviewed were conducted in a wide range of locations, such as Europe, Asia, and North America. No reviewed studies were conducted in South America or India. The mean prevalence by location uncovered by those studies was much lower in Asia (1.4%) and Africa (2.8%) than that in Europe (7.2%) and North America (10.1%). The prevalence of hip OA was generally higher in men (8.5%) than in women (6.9%). Prevalence of hip OA was correlating strongly and increasing progressively with age and reached 14% in the 85-or-above age group. The prevalence of hip OA in women was also significantly higher in the 75-to-79 and 85-or-above age groups than in the same age groups in men.

2.4.2 Etiopathogenesis and risk factors

Normally, an articulating joint surface is coated with a normal hyaline articular cartilage which is responsible for the unique biomechanical properties of the joint. The synovial fluid keeps it slippery and contributes to the properties of fluent gliding. In osteoarthritis, the quality of the articular cartilage deteriorates. It becomes soft and is often swollen. The cartilage surface generally roughens in the early stages of OA. In the later stages, fibrillation of cartilage and destruction of cartilage matrix occur even with

the underlying subchondral bone exposed. The cracks in the cartilage extend and propagate as a result of continuous mechanical trauma, which, together with some biochemical activities in the cartilage, leads to progressive loss of cartilage. As the cartilage breaks down, the thickness of the calcified cartilage area increases, and the microcracks in the cartilage initiates bone remodeling. The subchondral bone then becomes thickened as well and leads to subchondral sclerosis as a radiographic feature. Osteophytes formation can be found at the margins of the joint (44). Eventually, the synovial membrane, which is secretes synovial fluid into the joint cavity, becomes inflamed as a result of cartilage breakdown. The chondrocytes then produce inflammatory mediators and certain enzymes that can cause further damage to the cartilage (51).

Abnormal hip joint morphology is one of the most significant factors responsible for the onset of hip OA. In developmental dysplasia of the hip, the femoroacetbular contact surface area decreases. It results in the distribution of shear forces anterosuperiorly in the hip joint onto the acetabular rim, which subsequently leads to the degeneration of the anteroposterior acetabular labrum and degeneration of the articular cartilage over time. Eventually, the whole joint may fail, and hip OA may occur (28).

Similarly, in femoroacetabular impingement (FAI), the optimal weight distribution in the hip joint is also interrupted due to morphological abnormalities, such as a thickened, aspherical femoral head-neck junction, and a deepened acetabulum. The pathological contact of articular surfaces and loading patterns damage the acetabular cartilage and acetabular labrum. These connective tissues may then be delaminated from the bone, and a femoral head subluxation may also happen. Eventually. Failure and dysfunction of the hip joint can be expected (28).

Some studies have shown that being overweight, being obese, or having an increased body mass index (BMI) increases the risk of having hip OA (18, 41). As for genetic factors, some studies show that genetic inheritance accounts for around 60% of the risk for hip OA in women (25). Another study has shown that long-term exposure to standing or heavy-lifting at work also increases the risk of hip OA, which proves the influence of occupational factors (47).

As stated in the previous section, high age, female gender, and European and North American ethnicities are also some of the risk factors for hip OA.

2.4.3 Signs and symptoms

The most common symptom of hip OA is pain around the hip joint and the groin area (23), along with movement limitation, which becomes more frequent as the disease progresses (15). Most typically, the development of the pain proceeds and exacerbates slowly over time. Nevertheless, it can also have a rapid onset. Pain and stiffness that develop after sitting or resting, or in the morning, and can also happen. The pain may worsen with vigorous activity, while the hip stiffness and decrease in range of motion may also make it problematic to walk or bend down (23). Muscle spasm around the hip joint which promotes the joint deformity to set in may also be found. The thigh may be adducted and the limb may be shortened (15).

2.4.4 Classification and diagnosis

Osteoarthritis can be classified as primary or secondary. Primary osteoarthritis is idiopathic while secondary osteoarthritis which is caused by an underlying disorder such as joint trauma, Wilson's disease, hemochromatosis, gout, and neuropathic arthropathies (45).

In 1961, Outerbridge proposed a grading system for the macroscopic changes seen on the patella (33). This system was later successfully applied to other joints (44).

Grade	Description
1	Softening and swelling of the cartilage
2	Fragmentation and fissuring in an area half an inch or less in diameter
3	Fragmentation and fissuring in an area more than half an inch in diameter
4	Erosion of cartilage down to bone

Table 2.1: The Outerbridge classification – Classification and diagnosis – Osteoarthritis of the hip joint

Certain scoring or grading systems classify osteoarthritis according to the histological or microscopic changes and characteristics. These systems are not described in this thesis.

For diagnosis, the National Institute for Health and Care Excellence (NICE) (30) recommends diagnosing osteoarthritis clinically without investigations if a person 45 or over, has activity-related joint pain, and has either no morning joint-related stiffness or morning stiffness that lasts no longer than 30 minutes. Imaging investigations are not recommended to be part of the routine diagnostic pathway.

The American College of Rheumatology endorses 2 sets of classification or diagnostic criteria for hip osteoarthritis published by Altman et al. (4).

When both clinical and radiographic criteria are considered, the condition is classified as hip osteoarthritis when hip pain and at least 2 of the following features are found:

a) Erythrocyte sedimentation rate (ESR) is lower than 22 millimeters per hour (mm/hour)

b) Radiographic femoral or acetabular osteophytes

c) Radiographic joint space narrowing (superior, axial, and/or medial)

When radiographic findings are not considered, the condition is classified as hip osteoarthritis when hip pain and one of the following combinations is found:

a) Hip internal rotation is less than 15 degrees, and ESR is lower than or equal to 45 mm/hour (Hip flexion less than or equal to 115 degrees is used when ESR is not available

b) Hip internal rotation is greater than or equal to 15 degrees, pain on hip internal rotation, morning stiffness of the hip which lasts 60 minutes or less, and age is over 50

The classification system without incorporation of radiographic findings has a sensitivity of 86% and a specificity of 75%, while the method with both clinical and radiographic criteria has a sensitivity of 89% and a specificity of 91%.

For radiographic evaluation, the Kellgren-Lawrence scale (Kellgren & Lawrence, 1957) is one of the most widely used system for the grading of hip osteoarthritis and, based on the results on a study conducted by (39), it is the best predictor for a total hip replacement at follow-up. The system divides osteoarthritis into five grades as below (39, 22):

Grade	Description
0 (No osteoarthritis)	No radiographic signs of osteoarthritis
1 (Doubtful)	Possible narrowing of joint space and possible osteophyte formation
2 (Minimal)	Osteoarthritis definitely present. Definite narrowing of joint space and definite osteophyte formation
3 (Moderate)	Marked narrowing of joint space, definite osteophyte formation, some sclerosis and pseudocystic areas, and deformity of bone ends
4 (Severe)	Severe narrowing of joint space with sclerosis and pseudocysts, severe deformity of bone ends and osteophyte formation

Table 2.2: Kellgren-Lawrence scale classification – Classification and diagnosis – Osteoarthritis of the hip joint

2.4.5 Conservative management

Conservative non-pharmacological treatment options, such as physical therapy, weight reduction, and exercises, may be helpful in terms of pain reduction, and maintenance of function and joint mobility in the early, mild stages of hip osteoarthritis (23, 28). However, a study has shown that there is limited evidence which supports the use of physical therapy in patients with hip osteoarthritis. It was discovered that compared to sham treatment, physical therapy had no greater benefit on pain or function in adults with hip osteoarthritis (6).

For pharmacological management, medications such as paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs), cyclo-oxygenase 2 (COX-2) inhibitors, opioids, and intra-articular corticosteroids injections may be used (30, 38). Unfortunately,

these drugs are for pain relief with no disease-modifying effects (51). Hence, hip osteoarthritis, as a progressive degenerative disease, will still continue to progress even with these medications. Surgical management options such as total hip arthroplasty (THA), which is also known as total hip replacement (THR) may need to be considered when non-surgical management fails, the severe pain persists, and hip function becomes severely impaired (23). Total hip arthroplasty will be discussed in the next chapter.

2.5 Total hip replacement

2.5.1 Fixation of implants

Implants for total hip replacement usually involve an acetabular component and a femoral component. Nowadays, there are multiple ways to fix these components to the bone.

2.5.1.1 Cemented techniques

Cemented joint replacement involves the use of bone cement, which is usually a polymer called polymethylmethacrylate (PMMA). It works as a cement that connects and fixes the implant to the bone by filling the tight space between the two (15). Cemented implants provide high primary stability and it allows quick re-mobilization of patients. In addition to the custom-fitting of the implant to the bone, PMMA also acts as a buffer which helps distributing stress from the hard implant to the relatively more flexible bone (3).

2.5.1.2 Uncemented techniques

Uncemented implants are usually fit directly to the bone using the press-fitting techniques, after which osteointegration should take place and the implant should be incorporated into the bone, achieving permanent fixation. The femoral stem is first inserted pressed-fit into the medullar canal of femur, while the acetabular cup is anchored or screwed into the acetabular cavity. The surface of an uncemented implant is usually rough. This simulates bone growth and subsequent osteointegration. As this process can take some weeks, the patient would need to wait longer before loading the operated hip than with a cemented implant. Post-operative rehabilitation in this case would also take a longer time. Some of these implants may be coated with porous or bioactive materials in order to further stimulate bone growth and osteointegration. There are several advantages

of uncemented techniques, including the bio-compatibility of the materials and bone preservation (3)

2.5.1.3 Hybrid techniques

In hybrid hip replacement, one component is cemented while the other is uncemented. Hybrid techniques are used as it was found that the acetabular component and the femoral component may fail for different reasons. For example, the failure of a cemented acetabular component is often caused by bone lysis, while failure of the femoral component usually comes with a more mechanical cause. As a result, the acetabular component and the femoral component are often fixed using different techniques to prevent failure (3).

2.5.2 Common surgical approaches

2.5.2.1 Posterior approach

For the posterior approach, the patient is placed in the lateral decubitus position. The incision starts from approximately 5cm distal to the greater trochanter at the lateral center of the femoral diaphysis. It continues proximally to the greater trochanter and then curves slightly posteriorly towards the posterior superior iliac spine. The tensor fasciae latae is incised longitudinally and the gluteus maximus is also split along its fibers (27, 36, 34). This approach provides wide exposure of the acetabulum and femur during surgery (34) and spares the abductor musculature so that Trendelenburg limp is avoided (15).

2.5.2.2 Lateral approach

For this approach, the patient is placed in the lateral decubitus or supine position. The incision is made from a point 2 to 4 centimeters proximal to greater trochanter to a point 4 to 6 centimeters distal to the greater trochanter, along the line of femur. The gluteus medius and vastus lateralis are split during the process and the abductor hip abductor mechanism is compromised (27, 34). This approach provides adequate exposure to the proximal femur and acetabulum, and it reduces the risk of dislocation (27, 36). However, it can potentially damage the superior gluteal nerve (15).

2.5.2.3 Anterior approach

This is a relatively less invasive approach as it does not involve muscle splitting (27). The internervous and intermuscular planes between the tensor fasciae latae and sartorius, and between the rectus femoris and gluteus medius are utilized (34). The incision starts from a point approximately 3cm lateral and 3cm distal to the anterior superior iliac spine. It continues distally towards the fibular head for approximately 6 to 8 centimeters to keep it in line with the muscle belly of the tensor fasciae latae (27, 36). Exposure of the proximal femur is limited with this approach. The risk of dislocation is lower with this approach (36, 34). However, it is technically more demanding (34) and it requires special surgical kits (15).

2.5.3 Indications and contraindications

Total hip replacement is usually performed when other treatment modalities have failed to provide the desired outcomes (3). The primary indication for THR with end-stage articular disease is severe pain which causes limitation of activity (37). THR may then be used to eliminate pain, and improve mobility and quality of life. While primary

osteoarthritis is the most common pathological condition that requires a THR, other conditions such as osteonecrosis of the head of femur may also lead to a THR (3).

The main contraindications are an active local or systemic infections and any conditions such as cardiac diseases, that may cause complications which outweigh the benefits (3).

2.5.4 Complications

Listed below are some examples of THR complications (36, 15):

- Dislocation (Posterior approach has higher dislocation rates than the other two mentioned).
- Abductor muscle insufficiency (Common after lateral approach).
- Intra-operative fractures.
- Nerve injury
- Hemorrhage
- Fat embolism
- Venous thromboembolism and pulmonary embolism
- Hematoma
- Leg length discrepancy
- Pain

There are also some problems which may eventually lead to a revision THR. They include but are not limited to (15):

- Aseptic loosening
- Septic loosening (Joint infection)
- Fractures of implants
- Dislocation

2.6 Rehabilitation care before and after total hip replacement

2.6.1 Pre-operative rehabilitation

A detailed examination of the patient should precede any rehabilitation plans. The examination should include a kinesiological analysis, goniometric assessment, and a standardized assessment of the quality of everyday life (49).

According to Gray & Pratt (12), the pre-operative examination may include an assessment of the following items:

- Muscle strength (Including the potential of the upper extremities)
- Ranges of motion
- Neurological status
- Vital signs
- Endurance
- Functional level
- Safety awareness
- Existing edema, contractures, leg length discrepancies.

If the pre-operative assessment takes place in the patient's home, the therapist should check for the presence or absence of stairs, hallways, elevators and so on. Necessary safety adaptation such as the repositioning of furniture may also be recommended. The therapist should also consider if the patient requires medical assistive devices such as a shower chair or a walker (12).

Findings such as an antalgic gait pattern, decreased range of motion, avoidance behavior, contracture of hip flexors with accentuated lumbar lordosis, Trendelenburg sign, and hip pain or weakness may be observed on the patient. Muscle weakness in this case is a manifestation of the combination of disuse weakness, pain, and avoidance, but not true neurologic weakness (8).

The goals of pre-operative rehabilitation proposed by Gray & Pratt (12) and Votavová & Cikánková (49) differ in certain ways. According to Gray & Pratt (12), the

goals of pre-operative rehabilitation include teaching THR precautions for safety reasons and teaching a basic exercise program (in-bed exercises) which the patient can use during the post-operative phases. On the other hand, the goals set by Votavová & Cikánková (49) are as follows:

- Correct muscle imbalance in the hip area and decrease contractures
- Gait training with walking aids with reduced loading on the diseased extremity
- Self-care training with the non-operated limb
- Modification of breathing pattern
- Improvement of overall fitness
- Patient education concerning the early post-operative phase

2.6.2 Unsuitable hip movements after total hip replacement

The hip precautions (contraindicated motions) after THR for the prevention of hip dislocation suggested by different authors also differ. For instance, according to Gray & Pratt (12), the precautions after a THR using the posterolateral approach should be no hip flexion over 90 degrees, no hip adduction past the midline of the body, and no hip internal rotation. With the anterolateral approach, the precautions are the same as those after the posterolateral approach, but with the addition of no hip external rotation.

According to Gold Coast Health (11), the precautions after the anterior approach are no excessive hip internal or external rotation, no hip flexion with knee extended, and no forceful hip extension. After the posterior approach, the precautions are no hip flexion past 90 degrees, no hip adduction past mid-line, and no excessive hip internal or external rotation.

According to Votavová & Cikánková (49), instructions regarding the hip precautions are part of the post-operative rehabilitation. The precautions they suggest are no hip adduction past midline, no sitting at the edge of the bed, no hip flexion with knee extended, and no hip external rotation. Unlike the other writers, they did not specify the

surgical approach to which these precautions are applicable, and there is no specific limitation mentioned regarding hip flexion.

According to the Royal National Orthopaedic Hospital (42), the hip movements to be avoided are flexion over 90 degrees, adduction past the midline, and twisting of the operated leg. Again, the surgical approach is not specified.

I would like to highlight a few studies concerning hip precautions after THR that I came across:

1) A survey research conducted by Drummond et al. (10) has revealed that there is a lack of consensus in the reasoning using these precautions.
2) A systematic review done by Barnsley et al. (5) shows that the rate of dislocation after a THR using the anterolateral approach is low in general and the implementation of hip precautions does not help to prevent dislocation after an anterolateral THR. Contrarily, they are associated with a slower return to the activities of daily living (ADLs).
3) A study conducted by Restrepo et al. (40) shows that the incidence of dislocation after primary THR is low even without early post-operative restrictions, and that a no-restriction protocol does not increase the rate of early dislocation.

2.6.3 Post-operative rehabilitation

After the surgery, the physiotherapist should assess the neuromuscular and respiratory systems of the patient. An assessment may include of the following components (48, 52):

- Localized observation (swelling, joint contours, redness, atrophy and asymmetry of musculature, joint misalignment, etc.).
- Assessment of static posture.
- Gait and dynamic posture.

- Palpation (tenderness, increased warmth, swelling, muscle spasm, scarring, etc.).
- Assessment of ROM using a goniometer (and end-feel during passive movements).
- Assessment of sensation in dermatomes.
- Assessment of strength of muscles around the hips and other distal joints on both legs.
- Muscle length tests (Thomas test, modified Ober's test, piriformis test, hamstrings, quadratus lumborum, etc.).
- Anthropometric measurement of lengths and circumferences of both legs
- Assessment of pain (intensity, location, etc.).
- Assessment of ADL, self-care, and independence of the patient (dressing up, bed mobility, hygiene, etc.).

In the early post-operative phase, thromboembolic prevention is the main focus (49). This can be achieved with the ankle pump exercise, in which the patient performs maximum dorsal and plantar flexion of the ankles repetitively (12). Muscle training with isometric or active assisted concentric contraction of muscles such as the quadriceps femoris, hip abductors, and glutei should also begin in order to increase muscle contraction and improve the musculature and control of the lower extremities (49, 12). Repositioning and special aids such as heel booties should be employed to prevent bed sores (12). Physical therapy, especially cryotherapy, can be initiated shortly after the surgery (49). Bed mobility training, transfer training, and gait training usually begin on the second post-operative day if appropriate. The weight-bearing status is up to the discretion of the surgeon (49, 12).

Gradually, from around post-operative day 3 until discharge, hip abduction and extension exercises in the prone position are initiated, and daily prone positioning is important for the prevention of muscle contractures (49). The therapist should ensure that the patient is maintaining the post-operative precautions. Exercises for the upper extremities should begin in order to maintain or improve muscle strength. The patient should also become independent with transfers and with gait using assistive devices (49. 12). Before the patient being discharged from the hospital, the patient should be taught to do some home exercises (49) and it should be ensured that the patient is able to be independent with the exercise program (12).

Generally speaking, the therapy program for patients after total hip replacement may include the following:

In the acute phase (48),

- Cryotherapy (with ice packs, crushed ice, etc.) for the reduction of post-operative pain and edema around the surgical area.
- Education of hip precautions, and positioning of the operated extremity to maintain a safe position for the replaced hip joint. A cushion should be put between knees to prevent rotation and adduction past midline. De-rotation boots may also be used.
- Vascular gymnastics, positioning, and bandaging for thromboembolic prevention.
- Respiratory physiotherapy for the prevention of post-operative pulmonary complications such as pneumonia.
- Scar massage and therapeutic exercise to prevent development of scar contractures and adhesions.
- Compensation of muscle imbalance with muscle stretching and strengthening based on the results of the initial examination.
- Sitting, standing, walking depending on the condition of the patient. Verticalization on the first post-operative day is possible if the patient is in a generally good condition.
- Instructions for 3-point gait with relief of loading of the operated leg.
- Stairs training.
- Exercises for general conditioning.
- Sensorimotor training for improvement of posture and balance.
- ADL and self-care training (dressing up, bed mobility, hygiene, etc.)
- PNF may be used for improving muscle coordination, ranges of motion, stability, balance, muscle strength, endurance, and influencing muscle tone and so on (2), depending on the condition of the patient. Hip precautions should still be maintained.

The following may also be included in the subacute phase (48),

- Exercising in water can be used for a wide range of purposes, such as muscle strengthening, relaxation of muscle spasm, enhancement of cardiovascular fitness (53)
- Selective electrostimulation after electrodiagnosis in which the intensity-time (I/T) curve is determined, in case of post-operative.
- Low level laser therapy for promotion of wound healing.

3 SPECIAL PART

3.1 Methodology

This part of the thesis contains a case study on the post-operative, in-patient rehabilitation care received by a 71-year-old male patient who underwent a total replacement of the right hip joint due to coxarthrosis. The case study includes a comprehensive anamnesis of the patient and an initial kinesiological analysis which I performed on the patient. Some short-term goals and long-term goals of rehabilitation were established after the initial kinesiological analysis. Therapy progress has been documented as part of the case study. After all the therapy sessions, a final kinesiological analysis was performed in order to evaluate the effects of the used therapeutic methods on the patient. The patient showed some improvements after the therapy program.

The case study is based on the 80-hour clinical placement which I undertook at the Revmatologický ústav (Institute of Rheumatology) in Prague, Czech Republic, on weekdays during the period 4th February 2019 to 15th February 2019. Working hours started at 08:00 and ended at 16:00 every day.

There were 2 therapy sessions every day, a morning session and an afternoon session. The total number of examination and therapy sessions that I had with the patient was 16. The afternoon sessions were mostly short session reserved for verticalization and gait training only. The duration of each morning session was between 30 to 45 minutes.

All the physiotherapy procedures I performed during the placement were what I have learnt during my bachelor's studies in physiotherapy at the Faculty of Physical Education and Sport of Charles University, Prague, Czech Republic. No invasive methods were employed. Specific descriptions of the therapeutic procedures used have been included in the section "3.7 Therapy progress" of this thesis.

The subject of the case study signed an informed consent prior to the implementation of all examination and therapeutic procedures, as well as the incorporation of the case study into this thesis. This research project was approved by the Ethics Committee of the Faculty of Physical Education and Sport of Charles University under the registration number 076/2019.

3.2 Anamnesis

Name of Patient: M. C.

Gender: Male

Year of Birth: 1947

Diagnosis (according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) (50):

M15.0 Primary generalized (osteo)arthrosis

Z96.6 Presence of orthopaedic joint implants — Hip-joint replacement (total)

Personal Anamnesis:

St.p. revision TEP of the right hip with the posterior approach. Operation performed at Fakultní Nemocnice v Motole (Motol University Hospital) on 25th January 2019. Sutures to be removed in 12 to 14 days from the day of surgery.

TEP of the right hip in December 2004 due to coxarthrosis at grade 3-4. Re-operation in August 2009. TEP of the left hip in November 2007.

Arthrosis of DIP, PIP, MTP joints. Incipient rhizarthrosis, right side after hemiarthroplasty, left side after corrective surgery.

Psoriasis since 1992, yet no confirmation of psoriatic arthritis.

Periarthritis humeroscapularis on the right side without movement restrictions. Tenosynovitis at the attachments of biceps brachii according to ultrasound in Februrary 2012.

Algic syndrome in low back with prolapsed disc L4/5 and protrusion of L5/S1 with nerve root compression on the right side according to the CT scan in August 2002 without signs of nerve root syndrome.

Fractures of ribs in 1998.

Manio-depressive syndrome.

Hypertension, hypercholesterolemia, hyperuricemia.

Pharmacological anamnesis:

Tamsulosin 0.4mg tablet 0-0-1-0, Geratan 1200mg 2-2-0-0, Lorista 50mg tablet 1-0-0-0, Mirtazapin 30mg tablet 0-0-1-0, Duspatalin 200mg tablet 1-0-0-0, Grimodin 300mg tablet 1-1-0-0, Clexane 0.6ml subcutaneously 0-0-1-0. No specific rheumatology medications.

Allergies:

Penicillins

Abuses:

Non-smoker. Always drinks beer with food. Strong alcohol occasionally.

Family anamnesis:

Brother had tuberculosis at the age of 5. Mother had lung cancer. No other monitored diseases. Rheumatism runs in family. Father had psoriasis without joint issues.

Social anamnesis:

Patient is living with his girlfriend in an apartment in a house. Around 5 stairsteps between his apartment and the main entrance of the building.

Occupational history:

Retired. Has been receiving full invalidity pension since 1999 due to maniodepressive syndrome. Previously a train driver and had jobs which required hard physical labor.

3.3 Previous rehabilitation

The patient underwent “standard rehabilitation” after his first right hip replacement at the Institute of Rheumatology in December 2004 according to the medical records.

After the left hip replacement in 2007 at the Institute of Rheumatology, the patient received 20 sessions of individual therapeutic physical education for the replaced hip joint. The sessions lasted 30 minutes each. Soft tissue techniques were used on the scar. The patient was instructed to walk with 2 French crutches (forearm crutches) without weight-bearing on the operated leg. Elastic bandage was used on the operated leg.

After the right hip replacement at the Motol University Hospital on 25th January 2019, the patient was hospitalized there and received “standard rehabilitation” until 31 January 2019. The doctor ordered thromboembolic prevention for 6 weeks.

3.4 Physiotherapy examination and therapeutic procedures ordered by the doctor

Indication for Physiotherapy:

St.p. TEP of the right hip joint

Objective to Be Achieved:

Improvement of mobility

Prescribed procedures:

Individual therapeutic physical education — Conditioning and analytical methods

Individual therapeutic physical education — Instruction

Verticalization and gait training

Soft tissue techniques

Initial kinesiological analysis

Follow-up kinesiological analysis

Mobilization

3.5 Initial kinesiological analysis

3.5.1 Status praesens

Date: 8 February 2019

Objective:

Height: 177cm Weight: 70kg Body mass index (BMI): 22.3 Ectomorph

11 days after surgery.

The patient was oriented, lucid, cooperative, and afebrile. He was breathing normally. No jaundice or cyanosis. No signs of dehydration. Elastic bandage covering the right lower extremity (LE) from metatarsals to mid-thigh. No varices or hematomas under the bandage. Sutures not yet removed. Surgical scar covered with sterile dressing. Slight edema around the surgical site.

Subjective:

The patient was feeling some pain around the right hip during movements, especially near the scar. 5-6 on the visual analogue scale (VAS) during movements. No pain at rest. The patient was not able to describe the character of pain. He reported that he was able to eat, dress up, and go to the toilet alone with 2 crutches. He felt that his right leg was weak.

3.5.2 Postural examination (static)

The patient was standing with 2 forearm crutches during the examination to make the operated leg non-weight-bearing, as instructed by the doctor. The body of the patient was stable during the examination.

Postero-anterior view:

Feet were hip-width apart and in slight external rotation. Bilateral hallux valgus. Weight-bearing was more on the medial aspect of the left foot. Right foot lower extremity was resting on the ground but was not loaded. Left ankle was in a slight valgus position. Knees were in correct alignment. Visible muscle wasting in the areas of hamstrings on both legs. Left hip was slightly elevated. Trunk was slightly bending towards the right side. Forearm crutches in both hands. Shoulders were slightly elevated. Head was bending slightly towards the left side.

Side view:

Left knee and hip in semi-flexion when loaded. Right leg in flexion. Trunk in slight rotation towards the right side. Decreased lumbar lordosis. Slightly increased thoracic kyphosis. Shoulders and head were in slight protraction. The whole body was in slight anterior deviation as the patient tried to shift his weight over the crutches.

Antero-posterior view:

Bilateral hallux valgus. Visible muscle wasting in the quadriceps areas on both legs. Right hip was slightly elevated. Trunk was slightly bending towards the right side. Shoulders were slightly elevated. Head was bending slightly towards the left side.

Palpation of pelvis:

The iliac crest, anterior superior iliac spine (ASIS), and posterior superior iliac spine (PSIS) were all higher on the left side.

Breathing pattern observation:

The patient had an abdominal breathing pattern, in standing, sitting, and the supine position.

3.5.3 Gait analysis

The patient was walking with 2 forearm crutches during the examination to make the operated leg non-weight-bearing. The patient adopted a 3-point swing-to gait pattern (operated leg and crutches forward, then unaffected leg forward), as instructed by his doctor. He was generally familiar with the use of forearm crutches due to his previous experiences. The patient was stable while walking.

The right knee and hip were in flexion throughout the examination. The patient was walking slowly and the steps were small, but the rhythm was regular. Physiological gait cycle was not observed as the patient was trying to shift his weight mainly to the left forefoot and then propel his body forward by doing a jump. The left hip was in external rotation. Extension of the left hip minimal. Trunk was in hyperkyphosis. Shoulders were protracted. Head was in protrusion and slight flexion as the patient tried to look down to the floor. The patient could walk around 50 meters before he needed to sit down for a break. Natural trunk rotation and arm swing were not observed due to the use of the crutches.

3.5.4 Anthropometry

The distances recorded in this section were measured using a measuring tape when the patient was in the supine position. All distances were measured in centimeters (cm).

Lengths	Left lower extremity	Right lower extremity
Anatomical length of the whole extremity (Greater trochanter to lateral malleolus)	93	94

Functional length of the whole extremity (ASIS to medial malleolus)	90	91
Functional length of the whole extremity (Umbilicus to medial malleolus)	98	99
Length of thigh (Greater trochanter to knee)	51	52
Length of calf (Head of fibula to lateral malleolus)	39	39

Table 3.1: Lengths of the lower extremities – Anthropometry – Initial kinesiological analysis

Circumferences	Left lower extremity	Right lower extremity
Circumference of thigh (15cm above patella)	38	34
Circumference of thigh (10cm above patella)	36	33
Circumference of knee joint	36	37
Circumference of calf (around the area with the highest volume)	31.5	31.5
Circumference of ankle (Around lateral and medial malleoli)	27.5	27.5

Table 3.2: Circumferences of the lower extremities – Anthropometry – Initial kinesiological analysis

3.5.5 Goniometry

The reference values for ranges of motion (ROM) used in this section were the average values suggested by Kendall et al. (20). The active ranges of motion (AROM) and passive ranges of motion (PROM) were measured in angular degrees (°) with a plastic universal goniometer and recorded using the International Sagittal-Frontal-Transverse-Rotation (S.F.T.R) Method according to Gerhardt & Russe (43). Measurement procedures suggested by Norkin & White (31) were employed. Adduction, internal rotation, and external rotation of the right hip joint were not measured, as recommended by UNIFY ČR (48).

(xxx = Not tested; F90 = In 90° flexion)

	Left lower extremity		Right lower extremity		
	AROM	PROM	AROM	PROM	Reference values
	Hip joint				
S	5-0-90	5-0-100	0-0-60	0-0-75	10-0-125
F	25-0-10	25-0-10	10-0-xxx	20-0-xxx	45-0-10
R (F90)	20-0-10	25-0-10	xxx-0-xxx	xxx-0-xxx	45-0-45
	Knee joint				
S	0-0-110	0-0-120	0-0-xxx	0-0-xxx	0-0-140
	Ankle joint				
S	5-0-30	10-0-40	5-0-30	10-0-40	20-0-45
R	15-0-30	15-0-30	15-0-30	15-0-30	20-0-40

Table 3.3: Goniometry – Initial kinesiological analysis

3.5.6 Muscle strength testing

The classification system of muscle strength introduced by Janda (17) was used. This system classifies muscle strength into 6 levels, *Grade 0* to *Grade 5*.

Grade 5: A normal, very strong muscle with a full range of movement and is able to overcome considerable resistance.

Grade 4: A muscle with good strength and a full range of movement, and is able to overcome moderate resistance.

Grade 3: A muscle with a complete range of movement against gravity only when resistance is not applied.

Grade 2: A very weak muscle with a complete range of motion only when gravity is eliminated by careful positioning of the patient.

Grade 1: A muscle with evidence of slight contractility but no effective movement.

Grade 0: A muscle with no evidence of contractility.

The muscle strength tests were performed with adaptations to the actual condition of the patient. Abduction and adduction of the left hip joint were performed when the patient was in the supine position as he was not able to lie on his right side. Adductors of the right hip were not tested as a full range of adduction was contraindicated.

(xxx = Not tested)

Movements performed	Primary muscles involved	Left lower extremity	Right lower extremity
	Hip joint		
Flexion	Iliopsoas	4	2
Extension	Gluteus maximus Biceps femoris (long head) Semimembranosus Semitendinosus	3	1

Adduction	Adductor magnus Adductor longus Adductor brevis Gracilis Pectineus	4	xxx
Abduction	Gluteus medius Gluteus minimus Tensor fasciae latae	4	2
	Knee joint		
Flexion	Biceps femoris Semimembranosus Semitendinosus	4	3
Extension	Quadriceps femoris	4	2
	Ankle joint		
Plantar flexion	Triceps surae	4	4
Plantar flexion with flexed knee	Soleus	4	4
Inversion with dorsal flexion	Tibialis anterior	4	4
Inversion with plantar flexion	Tibialis posterior	4	4
Eversion with plantar flexion	Peroneus longus Peroneus brevis	4	4

Table 3.4: Muscle strength testing – Initial kinesiological analysis

3.5.7 Muscle length testing

Test procedures and grading system according to Janda (16) were used.

(xxx = Not tested)

Muscles	Left lower extremity	Right lower extremity
Gastrocnemius	0	0
Soleus	0	0
Iliopsoas	xxx	1
Rectus femoris	xxx	1
Hamstrings	0	2
Hip adductors (Pectineus, adductor brevis, adductor magnus, adductor longus, semitendinosus, semimembranosus, and biceps femoris)	2	2

Table 3.5: Muscle length testing – Initial kinesiological analysis

3.5.8 Soft tissue examination

Test procedures according to Lewit (24) were used. The examination was focused on the lower extremities and the pelvic region.

Skin and subcutaneous tissues:

It was generally dry. Psoriatic patches could be seen and were especially pronounced over the knee joints. No hematoma was observed. Sutures not yet removed. Surgical wound covered with sterile dressing. Area around the surgical site was slightly swollen and slightly warmer, compared to the other side of the body. Increased resistance could be felt when the skin around the right hip was examined with fingertips, in all directions away from the sterile dressing.

Fascia:

A rotational approach around the longitudinal axis of the examined segments was used. Increased resistance could be felt around the hip, knee, and ankle joints on both sides, but the increase of resistance around the right hip area was more prominent.

Muscle palpation:

No pain was experienced by the patient upon palpation

Muscles	Left lower extremity	Right lower extremity
Iliacus	Normal	Hypertonic
Psoas major	Normal	Hypertonic
Rectus femoris	Normal	Hypertonic
Gluteus maximus	Hypotonic	Hypotonic
Hamstrings	Hypotonic	Hypotonic
Hip adductors	Hypertonic	Hypertonic
Piriformis	Normal	Hypertonic
Triceps surae	Normal	Normal

Table 3.6: Muscle palpation – Soft tissue examination – Initial kinesiological analysis

3.5.9 Joint examination

Joint play techniques according to Lewit (24) were used.

Joints	Left lower extremity	Right lower extremity
Patella (Latero-laterally and cranio-caudally)	Normal	Slight restriction in both medio-lateral and latero-medial directions
Knee joint (Latero-laterally)	Normal	Slight restriction in both medio-lateral and latero-medial directions
Tibiofibular joint (Medio-dorsally and latero-ventrally)	Normal	Normal
Talocrural joint (Dorsal push)	Normal	Normal
Tarsometatarsal/Lisfranc joint (Dorsal push)	Restricted	Restricted
Transverse tarsal/Chopart joint (Dorsal push)	Normal	Normal
Metatarsophalangeal (MTP) joint (Dorso-plantarly)	All restricted in all direction, especially for the 1st MTP joint	All restricted in all direction, especially for the 1st MTP joint
Proximal interphalangeal (PIP) joint of foot (Dorso-plantarly and latero-laterally)	All restricted, especially in the latero-lateral directions	All restricted, especially in the latero-lateral directions
Distal interphalangeal (DIP) joint of foot (Dorso-plantarly and latero-laterally)	All restricted, especially in the latero-lateral directions	All restricted, especially in the latero-lateral directions

Table 3.7: Joint examination – Initial kinesiological analysis

3.5.10 Neurological examination

Deep tendon reflexes in the lower extremities:

Reflexes	Left lower extremity	Right lower extremity
Patellar reflex	Normal	Normal
Achilles reflex	Normal	Normal
Medioplantar reflex	Normal	Normal

Table 3.8: Deep tendon reflexes in the lower extremities – Neurological examination – Initial kinesiological analysis

Deep (proprioceptive) sensation in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Sense of joint position	Normal	Normal
Sense of movement of body segments	Normal	Normal

Table 3.9: Deep (proprioceptive) sensation in the lower extremities – Neurological examination – Initial kinesiological analysis

Superficial (exteroceptive) sensation in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Tactile sensation	Normal	Normal

Table 3.10: Superficial (exteroceptive) sensation in the lower extremities – Neurological examination – Initial kinesiological analysis

Cortical sensory functions in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Graphesthesia	Normal	Normal
2-point discrimination	Normal	Normal
Touch localization (Superomedial thigh, medial knee, medial ankle, mid-dorsum, lateral ankle)	Normal	Normal

Table 3.11: Cortical sensory functions in the lower extremities – Neurological examination – Initial kinesiological analysis

3.5.11 Screening for deep vein thrombosis (DVT)

Homan's sign was absent.

3.5.12 Conclusion of the initial kinesiological analysis

Sutures had not been removed after the surgery which was done 11 days ago. Slight edema around the operated area. The patient was mainly affected by the pain he experienced while moving the right hip (5-6 on VAS) and problems with mobility.

The right lower extremity could not yet be weight-bearing. Left knee and hip in slight semi-flexion. Right leg in flexion. Visible general muscle hypotrophy in the lower extremities. Pelvis elevated on the left side. Trunk slightly bending and rotating towards the right side. Slightly increased thoracic kyphosis. Shoulders elevated and protracted.

Head in slight lateroflexion towards the left side and in slight protrusion. The patient constantly tried to shift his weight over the crutches which resulted in a general anterior deviation of the body.

The patient was instructed to use the 3-point gait during walking, with complete relief of weight on the right leg. He kept the right knee and hip in slight flexion during gait. The pace of gait was slow. Steps were small. The patient tried to shift his weight to the left leg and the propel his body forward with a slight jump. Left hip was in external rotation. Trunk was in hyperkyphosis. Shoulders and head protracted. The patient had a tendency of looking down to the floor during gait.

The right hip had significantly decreased ROM due to the pain the patient was suffering. Active hip flexion reached 60 degrees and 75 passively. Hip abduction was significantly limited on both sides. Left hip had significantly limited ranges of rotation. ROM of the ankle joints were rather satisfactory, except for both active and passive dorsal flexion on both sides.

All muscles of the right hip and knee joints tested were markedly weak. Strength of right hip flexors, abductors, and right knee extensors was at grade 2. Right knee flexors at grade 3. Right hip extensors at grade 1. Strength of muscles for ankle movements were symmetrical (grade 4) on both sides.

The right iliopsoas and rectus femoris were slightly shortened. The right hamstrings, and hip adductors on both sides were greatly shortened.

Restriction could be found over the soft tissues around the right hip. Fasciae around the knee and ankle joints on both sides were also restricted. Most muscles tested in the right LE were in hypertonicity.

On the left side, the tarsometatarsal, MTP, PIP, and DIP joints were all restricted. On the right side, the patella, knee, tarsometatarsal, MTP, PIP, and DIP joints were restricted.

3.6 Rehabilitation plans

3.6.1 Short-term rehabilitation plan

1) Thromboembolic prevention
2) Instructions for prevention of dislocation of the right hip
3) Pain relief
4) Reduction of edema over the operated extremity
5) Scar therapy and instructions for massaging the scar after removal of stitches
6) Improvement of ROM of the right hip joint
7) Relaxation of hypertonic muscles (Right iliopsoas and rectus femoris, bilateral hip adductors) in the LEs
8) Stretching of the shortened muscles (right iliopsoas, hamstrings and rectus femoris, bilateral hip adductors) in the LEs
9) Mobilization of the restricted joints (right patella and knee joint in the latero-lateral direction, MTP joints of both feet in all directions, PIP and DIP joints of both feet in the latero-lateral direction) in the LEs
10) Correction of static posture
11) Verticalization and gait training
12) Instructions for stair-climbing
13) General conditioning/Improvement or maintenance of strength and mobility of the upper extremities

3.6.2 Long-term rehabilitation plan

1) Improvement of mobility with gradually increased loading of the right LE and reduction of the use of walking aids
2) Removal soft tissue restrictions in the LEs in areas other than the right hip region
3) Increase of regular physical activities and improvement of quality of activities of daily living
4) Improvement of overall physical condition
5) Improvement/maintenance of muscle condition

3.7 Therapy progress

3.7.1 Therapy session 1

Date: Morning, 5 February 2019, 11 days after surgery

Goals of this therapy session and procedures performed:

Initial kinesiological analysis.

The patient was already informed about the transfer techniques, contraindicated movements, and the recommended gait pattern with crutches right after the surgery. He was able to demonstrate those techniques and the 3-point gait pattern in which the right leg is not loaded correctly when he was requested to do so. No correction of the use of the transfer techniques or the gait pattern was therefore required.

3.7.2 Therapy session 2

Date: Afternoon, 5 February 2019, 11 days after surgery

Status praesens:

As in Section 3.3 Status praesens.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – The patient was in the supine position. He was first instructed to do repetitive active dorsal flexion (15 times) and plantar flexion (15 times) of the ankles, as well as circumduction in both clockwise (15 times) and counter-clockwise (15 times) directions. An overball was placed under the left ankle of the patient

to help improve movement fluency. The patient was asked to do active flexion of the knee and hip (15 times) and then extend back to the original position (15 times). The overball was then placed under the right ankle and the patient was asked to repeat the flexion-extension exercise with the right leg. The right leg of the patient was fixed manually during the exercises to avoid hip rotation and adduction. The patient was also instructed to repeat the whole thromboembolic exercise program on his own every hour. He was also recommended to slightly elevate the lower extremities by inserting a pillow or blanket under his ankles.

Reduction of edema around the surgical site – The patient was lying on his left side with knees flexed to keep the body stable. A foam ball was used for a gentle massage around the surgical wound. The massage was done by rolling the ball in straight lines (20 times) or in small circles (20 times), but both in the caudo-cranial direction.

Relaxation of hypertonic muscles in the lower extremities – Post-isometric relaxation (PIR) and reciprocal inhibition (RI) of the hip adductors on both sides was performed. The principles of PIR and RI preferred by Lewit (24) were generally followed, but certain modifications and adaptations were made, depending on the patient's ability to cooperate and actual condition. For relaxation of the hip adductors on both sides, the patient was in the supine position. The extended left leg of the patient was abducted passively until the barrier was engaged. The pelvis was fixed from the ipsilateral side. The patient was instructed to resist the passive abduction isometrically with minimal force and keep the resistance for 10 seconds. He was then instructed to breathe in slowly and deeply, hold the breath for approximately 3 seconds and eventually breathe out and relax. Time for relaxation was around 30 seconds. This was repeated 3 times. RI was performed by stretching the adductors until the barrier was reached, and then asking the patient to perform isometric contraction of the hip abductors against the rhythmic repetitive resistance I was providing. This was repeated 10 times. PIR and RI of the hip adductors were then used on the left leg. PIR and RI of iliopsoas and rectus femoris on the right side were performed when the patient was lying on his left side, with similar procedures as those for the hip adductors.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – All movements were performed passively. For the stretching of the hip adductors on both sides and improvement of range of abduction on both sides, the patient was in the supine position. The hip adductors were stretched by abduction of

the extended leg. The muscles were stretched for 20 seconds and then 10 seconds of relaxation was allowed. This was repeated 10 times. For the improvement of range of flexion of the right hip joint, the patient hip was flexed passively with the knee fully flexed until the patient started to feel pain, and then placed back in the original position. This was repeated 10 times. Stretching of the hamstrings was done by passively extending the knee when the hip was flexed with the knee fully flexed. This was repeated 10 times.

Strengthening of the weak muscles in the lower extremities – Only the strengthening of the right knee and hip extensors was done in this session. An overball was placed under the right knee of the patient as the starting position. To strengthen the knee extensors, the patient was asked to do active knee extension by keeping the whole leg straight and holding it for 10 seconds. This was repeated 10 times. To strengthen the hip extensors, the patient was asked to press the knee down towards the overball while keeping the heel of the foot on the bed. This was repeated 10 times.

Instructions for prevention of dislocation of the right hip – The patient was instructed not to perform adduction and rotation of the right hip, as well as flexion over 90°. A cushion should be put between two legs when resting in bed and getting out of bed in order to maintain a safe position of the right hip joint.

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. Pain in the right hip was felt during the exercises. 5-6 on VAS but the patient was tolerating well.

The patient understood the exercises for thromboembolic prevention and could demonstrate them without instructions. He also understood the principles for prevention of right hip dislocation. No significant changes to the edema around the right hip. Bilateral hip adductors, and the right rectus femoris and iliopsoas were relaxed after PIR and RI. No significant increase in ROM after stretching and passive movements. Right knee and hip extensors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles due to pain.

3.7.3 Therapy session 3

Date: Morning, 6 February 2019

Status praesens:

12 days after surgery. Sutures not yet removed. Wound covered with sterile dressing. Right leg still wrapped with elastic bandage. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. Uneventful otherwise.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used on 5 February 2019.

Reduction of edema around the surgical site – Same procedures as those used on 5 February 2019.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used on 5 February 2019.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors and the right hamstrings using the same techniques as those used on 5 February 2019. Iliacus and psoas major on the right side were also stretched passively (10 times) in this session with the patient lying on his left side.

Strengthening of the weak muscles in the lower extremities – Strengthening of the right knee and hip extensors using the same techniques as those used on 5 February 2019. The right iliopsoas was strengthened by asking the supine patient to do isometric contraction (10 times. 10 seconds each) against resistance manually applied on the anterior aspect of distal thigh, when the hip was flexed at around 70° and knee fully flexed. Right hip abductors were also strengthened in the supine position by asking patient to do isometric contraction (10 times. 10 seconds each) against manually applied resistance. Right hip adductors were strengthened by placing an overball between the flexed knees

of the supine patient and then asking him to squeeze the ball with both knees (10 times. 10 seconds each).

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. Pain in the right hip was felt during the exercises. 5-6 on VAS but the patient was tolerating well.

The patient understood the exercises for thromboembolic prevention and could demonstrate them without instructions. No significant changes to the edema around the right hip. Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. No significant increase in ROM after stretching and passive movements. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles due to pain.

3.7.4 Therapy session 4

Date: Afternoon, 6 February 2019

Status praesens:

Same as in the morning.

Goals of this therapy session and procedures performed:

Verticalization and gait training – The patient could get off the bed and stand up all by himself. The patient was instructed to increase hip extension of the left leg during gait and maintain an upright posture of the body. He was also instructed to try to use his heel during gait instead of just jumping with the forefoot.

Results of therapy:

No orthostatic hypotension was observed. The 3-point gait pattern seemed better after some practice. The patient could maintain an upright posture with frequent prompts. Range of left hip extension also increased during gait. The patient could walk around 50 meters before needing to rest.

3.7.5 Therapy session 5

Date: Morning, 7 February 2019

Status praesens:

13 days after surgery. Sutures not yet removed. Wound covered with sterile dressing. Right leg still wrapped with elastic bandage. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. Slight soreness in the right hip adductors region after the stretching and exercises on yesterday (6 February 2019). Uneventful otherwise.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Reduction of edema around the surgical site – Same procedures as those used in the previous sessions.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – To maintain muscle strength and mobility of the left leg, active, non-assisted, concentric knee flexion and extension, as well as hip flexion, extension, adduction, and abduction on the left side were performed by the patient. Each movement was repeated 20 times. Strengthening of the right knee and hip extensors, the right iliopsoas, the right hip abductors and adductors using the same techniques as those used in previous sessions.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – The patient was asked to curl up the trunk with his legs flexed in the supine position (5 times). In the sitting position, the patient was asked to hold an overball with both hands and squeeze the ball (20 times), and then circumduction of the wrists in both directions (20 times each). Resisted flexion-extension of the elbows, and flexion-extension, abduction-adduction, and medial-lateral rotation of the shoulders (10 times each). The patient was instructed to add resistance to the movements by himself with a Thera-Band, by fixing it with one hand in one direction, while the other hand pulled the Thera-Band towards the opposite direction. For example, to strengthen the lateral rotators of the right shoulder, the patient was asked to keep both upper arms close to the body, elbow at 90° flexion, with both forearms pointing forward. Each hand was holding one end of the TheraBand. The left arm stayed in the starting position, while the right shoulder was doing lateral rotation. These exercises for the upper extremities were recommended to the patient as autotherapy as well.

Mobilization of the restricted joints in the LEs – Only the right patella and knee joint were mobilized during this session. Mobilization techniques according to Lewit (24) were used. The patella was shifted in both medio-lateral and latero-medial directions with repetitive springing (20 times). The knee joint was mobilized using the lateral gapping technique, in both medio-lateral and latero-medial directions (20 times).

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. Pain in the right hip was felt during the exercises. 5-6 on VAS but the patient was tolerating well.

The patient understood the exercises for thromboembolic prevention and could demonstrate them without instructions. Still slight edema around the right hip. Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Active and passive extension of the right hip could now reach 5°. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles due to pain. The patient understood how to perform the autotherapy for the upper extremities. There was still some resistance when mobilizing the right patella and knee joint, but the barriers became softer than before the mobilization.

3.7.6 Therapy session 6

Date: Afternoon, 7 February 2019

Status praesens:

Same as in the morning. The ROM of left hip extension looked better than yesterday (6 February 2019) but it was still limited. The patient was able to increase heel strike today.

Goals of this therapy session and procedures performed:

Verticalization and gait training – The patient could get off the bed and stand up all by himself. The patient was again instructed to try to increase left hip extension during gait and maintain an upright posture of the body. He was also instructed to keep the shoulders down (not elevated) during gait.

Results of therapy:

No orthostatic hypotension was observed. The range of left hip extension was getting better. The patient could maintain an upright posture and keep the shoulders down with frequent prompts. The patient could walk around 50 meters before needing to rest.

3.7.7 Therapy session 7

Date: Morning, 8 February 2019

Status praesens:

14 days after surgery. Sutures not yet removed. Wound covered with sterile dressing. Right leg still wrapped with elastic bandage. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. 4-5 on VAS. The patient was feeling stronger after doing the exercises for the upper extremities on his own. Uneventful otherwise.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Reduction of edema around the surgical site – Same procedures as those used in the previous sessions.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – Exercises for the left leg, and the right knee extensors, the right iliopsoas were the same as those used in previous sessions. Strengthening of the right hip extensors, abductors, and adductors was done with isometric contraction in the prone position this day. The patient was also asked to do the bridging exercise for strengthening the hip extensors. The patient was in the supine position for this exercise. He was asked to keep both feet flat on the bed, tighten the buttocks while lifting his pelvis up towards the ceiling, and stay in this position for 5 seconds, then relax and repeat 5 times.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – Same exercises as those used in the previous sessions.

Mobilization of the restricted joints in the LEs – Only the right patella and knee joint were mobilized during this session. Mobilization techniques according to Lewit (24) were used.

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. Pain in the right hip was felt during the exercises. The patient said it was less painful moving the right hip today but it would still be around 4-5 on VAS. The patient was tolerating well. No discomfort felt during or after the mobilization of the right patella and knee joint.

The patient understood the exercises for thromboembolic prevention and could demonstrate them without instructions. Still slight edema around the right hip. Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Active and passive extension of the right hip could now reach 5°. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically. The patient was able to do the bridging exercise but without full hip extension. He found this exercise difficult. The patient understood how to perform the autotherapy for the upper extremities. There was still some resistance when mobilizing the right patella and knee joint, but the barriers became softer than before the mobilization. After all the therapeutic procedures, the fasciae around the hip joints and the knee joints became less restricted. The skin near the wound was also getting less restricted. The

tonicity of the right gluteus maximus and hamstrings became higher than it was during the initial kinesiological analysis.

3.7.8 Therapy session 8

Date: Afternoon, 8 February 2019

Status praesens:

Same as in the morning and the patient said he believed the pain was really getting better. The patient was able to keep the improved hip extension and keep the shoulders down during gait. The patient still had a tendency to go into trunk flexion and shift weight towards the left side.

Goals of this therapy session and procedures performed:

Verticalization and gait training – The patient could get off the bed and stand up all by himself. The patient was again instructed to try to increase left hip extension during gait, maintain an upright posture of the body, and keep the shoulders down (not elevated). He was also instructed shift slightly more weight over the medial side of the left food and the right crutch.

Results of therapy:

No orthostatic hypotension was observed. The improved range of left hip extension was maintained. The patient could maintain an upright posture and keep the shoulders down. The patient was starting to find it hard to correct everything at the same time and was uncoordinated sometimes. The patient could walk around 100 meters before needing to rest.

3.7.9 Therapy session 9

Date: Morning, 11 February 2019

Status praesens:

17 days after surgery. Sutures, sterile dressing, and elastic bandage removed. Slight edema and redness around the approximately 20-centimerter scar, which was on the lateral aspect of the right hip. Slight increase in temperature locally around the scar. No scar hypertrophy. The patient felt happy to have the stitches removed. The patient found it painful when some firmer areas of the scar were palpated. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. 4-5 on VAS. The patient was feeling stronger after doing the exercises for the upper extremities on his own. The right LE should stay non-weight-bearing. Uneventful otherwise.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Reduction of edema around the surgical site – Same procedures as those used in the previous sessions.

Scar management – Soft tissue techniques (STT) according to Lewit (24) were used. The STTs used included sustained applications of pressure in S-waves and C-waves. Each technique was used 10 times. The patient was instructed to do it on his own twice a day. However, as he could not comprehend the concept of "waiting for release", he was asked to just hold the wave for 20 seconds and let it go, and repeat 10 times twice a day.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – Exercises for the left leg, and the right knee extensors, the right iliopsoas were the same as those used in previous sessions. Strengthening of the right hip extensors, abductors, and adductors was done with isometric contraction in the prone position this day. The patient was also asked to strengthen the right iliopsoas by trying to active bringing the thigh towards the trunk with the knee flexed. The patient was asked to do the bridging exercise as it was done on 8 February 2019.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – Same exercises as those used in the previous sessions.

Mobilization of the restricted joints in the LEs – Only the Lisfranc joints on both sides were mobilized during this session. It was done according to Lewit (24) by fixing the distal row of tarsal bones with one hand, and with the other hand shifting the metatarsal bones dorsally with repetitive springing (20 times).

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. The patient felt some pain during the scar massage. Hyperemia was induced after the massage. The area around the scar also became slightly more swollen than before the massage. He understood and was able to perform the adapted version of scar massage. Pain in the right hip was still felt during the exercises. 3-4 on VAS. The patient was tolerating well. No discomfort felt during or after the mobilization of the Lisfranc joints.

Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Active and passive extension of the right hip could still reach 5°. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles due to pain. Still no full hip extension during the bridging exercise. The patient was asked to continue with perform the autotherapy for the upper extremities. No significant improvement after the mobilization of the Lisfranc joints. The soft tissues around the right hip joint became less restricted. The tonicity of the right gluteus maximus and hamstrings became higher than it was during the initial kinesiological analysis, while the rectus femoris was becoming more relaxed.

3.7.10 Therapy session 10

Date: Afternoon, 11 February 2019

Status praesens:

Same as in the morning. The patient said that he would like to try the stairs out.

Goals of this therapy session and procedures performed:

Stair-climbing training – The patient could walk on flat ground without significant stability issues, so we started practicing stair-climbing as he wished. The patient was informed about the gait patterns for going up and going down stairs. For ascending stairs, the patient was instructed to step up with the left leg, keep the right leg raised and behind the body, and then bring both crutches to that step. For descending stairs, the patient was asked to bring both crutches down to the step below, keep the right leg in front of the body, and then step down with the left leg. The patient just tried 3 steps down and 3 steps up in this session.

Results of therapy:

No orthostatic hypotension was observed. The patient found it quite tiring to climb the stairs with crutches. His body was generally stable during the practice.

3.7.11 Therapy session 11

Date: Morning, 12 February 2019

Status praesens:

18 days after surgery. Slight edema and redness around the scar. The patient felt happy to have the stitches removed. The patient found it painful when some firmer areas of the scar were palpated. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. 3-4 on VAS. The patient had been doing the thromboembolic prevention exercises, the exercises for the upper extremities, and scar massage on his own. No discomfort after the stair-climbing practice yesterday (11 February 2019). Uneventful otherwise.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Reduction of edema around the surgical site – Same procedures as those used in the previous sessions.

Scar management – Same procedures as those used on 11 February 2019.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – Exercises for the left leg, and the right knee extensors, the right iliopsoas were the same as those used in previous sessions. Strengthening of the right hip extensors, abductors, and adductors was done with isometric contraction in the prone position this day. The patient was also asked to strengthen the right iliopsoas by trying to active bringing the thigh towards the trunk with the knee flexed. Bridging exercise as it was done in the previous sessions.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – Same exercises as those used in the previous sessions.

Mobilization of the restricted joints in the LEs – Only the Lisfranc joints on both sides were mobilized during this session. Mobilization techniques according to Lewit (24) were used.

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. The patient felt some pain during the scar massage, especially when the firmer nodules of the scar were being pressed on. Hyperemia was induced after the massage. He understood and was able to perform the adapted version of scar massage. Pain in the right hip was still felt during the exercises. 3-4 on VAS. The patient was tolerating well. No discomfort felt during or after the mobilization of the Lisfranc joints.

Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Active and passive extension of the right hip could still reach 5°. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles. Bridging exercise as it was done in the previous sessions. The patient was asked to continue with perform the autotherapy for the upper extremities. No significant improvement after the mobilization of the Lisfranc joints. The soft tissues around the right hip joint became less restricted. The tonicity of the right gluteus maximus and hamstrings became higher than it was during the initial kinesiological analysis, while the hypertonic muscles treated were becoming more relaxed.

3.7.12 Therapy session 12

Date: Afternoon, 12 February 2019

Status praesens:

Same as in the morning. The patient would like to continue with the stair-climbing training.

Goals of this therapy session and procedures performed:

Verticalization and gait training – The patient could get off the bed and stand up all by himself. The patient was again instructed to try to increase left hip extension during gait, maintain an upright posture of the body. The slight protraction and elevation of shoulders, as well as the slight protrusion of the head, were corrected.

Stair-climbing training – The patient could not clearly remember the gait patterns for ascending and descending stairs. Instructions that were the same as those given on 11 February 2019 were given again. The patient walked 10 steps down and 10 steps up in this session. No specific correction of his posture was performed during stair-climbing.

Results of therapy:

No orthostatic hypotension was observed. The patient had to walk more slowly in order to maintain a correct posture during gait. The patient could walk 10 stairsteps down easily but he found it too exhausting to go up. His body was generally stable during the stair practice.

3.7.13 Therapy session 13

Date: Morning, 13 February 2019

Status praesens:

19 days after surgery. Slight redness around the scar. The patient found it painful when some firmer areas of the scar were palpated. Patient felt well-rested and motivated. Pain in the right hip was persisting during movements. 3-4 on VAS. The patient had been doing the thromboembolic prevention exercises, the exercises for the upper extremities, and scar massage on his own.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Scar management – Same procedures as those used in previous sessions.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – Exercises for the left leg, and the right knee extensors, the right iliopsoas were the same as those used in previous sessions. Strengthening of the right hip extensors, abductors, and adductors was done with isometric contraction in the prone position this day. The patient was also asked to strengthen the right iliopsoas by trying to active bringing the thigh towards the trunk with the knee flexed. Bridging exercise as it was done in the previous sessions.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – Same exercises as those used in the previous sessions.

Mobilization of the restricted joints in the LEs – Only the Lisfranc joints on both sides were mobilized during this session. Mobilization techniques according to Lewit (24) were used.

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. The patient felt some pain during the scar massage, especially when the firmer nodules of the scar were being pressed on. Hyperemia was induced after the massage. He understood and was able to perform the adapted version of scar massage. Pain in the right hip was still felt during the exercises. 3-4 on VAS. The patient was tolerating well. No discomfort felt during or after the mobilization of the Lisfranc joints.

Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles. Bridging exercise as it was done in the previous sessions. The patient was asked to continue with perform the autotherapy for the upper extremities. No significant improvement after the mobilization of the Lisfranc joints. The soft tissues around the right hip joint became less restricted. The tonicity of the right gluteus maximus and hamstrings was improving.

3.7.14 Therapy session 14

Date: Afternoon, 13 February 2019

Status praesens:

Same as in the morning.

Goals of this therapy session and procedures performed:

Verticalization and gait training – The patient could get off the bed and stand up all by himself. The patient was again instructed to try to maintain an upright posture during walking. He was also asked to correct the protraction and elevation of shoulders, as well as the head protrusion. He had been reminded to look forward when walking instead of looking down all the time.

Stair-climbing training – The patient was able to demonstrate the gait patterns for stair-walking correctly. The patient was able to slowly go all the way down the stairs (around 40 steps) to the floor below by himself with the crutches. No specific correction of his posture was performed during stair-climbing.

Results of therapy:

No orthostatic hypotension was observed. The patient was able to follow my instructions for postural correction during gait and was able to correctly remember the instructions for stair-climbing. He was able to walk down around 40 stairsteps. Going up stairs was still more exhausting for him, so he chose to walk to the elevator and go up again to his room. He walked approximately 100 meters on flat ground.

3.7.15 Therapy session 15

Date: Morning, 14 February 2019

Status praesens:

20 days after surgery. Slight redness around the scar. Edema was almost completely gone. The patient still found it painful when some firmer areas of the scar were stretched during scar massage. Patient felt well-rested and motivated. Pain in the right hip was persisting but improving during movements. 1-2 on VAS. The patient had

been doing the thromboembolic prevention exercises, the exercises for the upper extremities, and scar massage on his own.

Goals of this therapy session and procedures performed:

Thromboembolic prevention – Same procedures as those used in the previous sessions.

Scar management – Same procedures as those used in the previous sessions.

Relaxation of hypertonic muscles in the lower extremities – PIR and RI of bilateral hip adductors, and the right iliopsoas and rectus femoris. Same techniques as those used in the previous sessions.

Stretching of the shortened muscles in the lower extremities and improvement of ROM of the right hip joint – Stretching of the bilateral hip adductors, the right hamstrings, and the right iliopsoas using the same techniques as those used in the previous sessions.

Strengthening of the weak muscles in the lower extremities – Exercises for the left leg, and the right knee extensors, the right iliopsoas were the same as those used in previous sessions. Strengthening of the right hip extensors, abductors, and adductors was done with isometric contraction in the prone position this day. The patient was also asked to strengthen the right iliopsoas by trying to active bringing the thigh towards the trunk with the knee flexed. Bridging exercise as it was done in the previous sessions.

General conditioning/Improvement or maintenance of strength and mobility of the upper extremities – Same exercises as those used in the previous sessions.

Mobilization of the restricted joints in the LEs – Only the Lisfranc joints on both sides were mobilized during this session. Same techniques as those used in previous sessions.

Results of therapy:

The patient was cooperative throughout the session and he felt a bit tired after all the exercises. The patient felt some pain during the scar massage, especially when the firmer nodules of the scar were being pressed on. Hyperemia could be seen after the massage. Pain in the right hip was still felt during the exercises. 1-2 on VAS. The patient

was tolerating well. No discomfort felt during or after the mobilization of the Lisfranc joints.

Bilateral hip adductors, and the right iliopsoas and rectus femoris were relaxed after PIR and RI. Right knee and hip extensors, right iliopsoas, and right hip adductors and abductors were strengthened isometrically, but the patient was still unable to perform active full-range concentric contraction of those muscles. Still no full hip extension during the bridging exercise, but the patient was starting to find this exercise easier than before. The patient was asked to continue with perform the autotherapy for the upper extremities. No significant improvement after the mobilization of the Lisfranc joints. The soft tissues around the right hip joint became less restricted. The tonicity of the right gluteus maximus and hamstrings was improving.

3.7.16 Therapy session 16

Date: Afternoon, 14 February 2019, 20 days after surgery

Goals of this therapy session and procedures performed:

Final kinesiological analysis.

3.8 Final kinesiological analysis

3.8.1 Status praesens

Date: 14 February 2019

Objective:

Height: 177cm Weight: 67kg Body mass index (BMI): 21.4 Ectomorph

20 days after surgery.

The patient was oriented, lucid, cooperative, and afebrile. He was breathing normally. No jaundice or cyanosis. No signs of dehydration. All sutures, sterile dressings, and elastic bandages had been removed. No varices or hematomas in the lower extremities. A 20-cm surgical scar on the lateral aspect of the right hip could be seen. Slight redness but no edema around the scar. No local increase in temperature. No scar hypertrophy.

Subjective:

The patient was still feeling some pain around the right hip during movements. 1-2 on VAS during hip movements with no pain at rest. No changes in his ability to eat, dress up, and go to the toilet. He felt happy that he could use the stairs now.

3.8.2 Postural examination (static)

The patient was standing with 2 forearm crutches during the examination to make the operated leg non-weight-bearing, as instructed by the doctor. The body of the patient was stable during the examination.

Postero-anterior view:

Feet were hip-width apart and in slight external rotation. Bilateral hallux valgus. Right foot lower extremity was resting on the ground but was not loaded. Weight distribution seemed to be even in the left foot. Knees were in correct alignment. Visible muscle wasting in the areas of hamstrings on both legs. Left hip was slightly elevated. Trunk was in an upright position. Forearm crutches in both hands. Shoulders were not elevated. Head was bending slightly towards the left side.

Side view:

Right leg in flexion. Trunk in slight rotation towards the right side. Decreased lumbar lordosis. Slightly increased thoracic kyphosis. Shoulders and head were in slight protraction. No anterior deviation of the whole body.

Antero-posterior view:

Bilateral hallux valgus. Visible muscle wasting in the quadriceps areas on both legs. Right hip was slightly elevated. Trunk was slightly bending towards the right side. Shoulders were slightly elevated. Head was bending slightly towards the left side.

Palpation of pelvis:

The iliac crest, anterior superior iliac spine (ASIS), and posterior superior iliac spine (PSIS) were all higher on the left side.

Breathing pattern observation:

The patient had an abdominal breathing pattern, in standing, sitting, and the supine position.

3.8.3 Gait analysis

The patient was walking with 2 forearm crutches during the examination to make the operated leg non-weight-bearing. The patient adopted a 3-point swing-to gait pattern. The patient was stable while walking.

The right knee and hip were in flexion throughout the examination. The patient had a moderate walking speed and a moderate stride length. Gait rhythm was regular. The patient was able to land on his heel and stand up straight before making the next step. The left hip was in external rotation. Extension of the left hip was sufficient. Shoulders were protracted but not elevated. Head was in protrusion and the patient had a tendency to look down to the floor while walking. The patient was able to demonstrate the correct patterns for ascending and descending stairs with crutches without prior recapitulation. The patient was walking in a much slower speed when ascending but he was more able to keep his body upright while ascending than during descending. He could walk approximately 150 meters before he needed to sit down and take a short break.

3.8.4 Anthropometry

The distances recorded in this section were measured using a measuring tape when the patient was in the supine position. All distances were measured in centimeters (cm).

Lengths	Left lower extremity	Right lower extremity
Anatomical length of the whole extremity (Greater trochanter to lateral malleolus)	93	94

Functional length of the whole extremity (ASIS to medial malleolus)	90	91
Functional length of the whole extremity (Umbilicus to medial malleolus)	98	99
Length of thigh (Greater trochanter to knee)	51	52
Length of calf (Head of fibula to lateral malleolus)	39	39

Table 3.12: Lengths of the lower extremities – Anthropometry – Final kinesiological analysis

Circumferences	Left lower extremity	Right lower extremity
Circumference of thigh (15cm above patella)	38	37
Circumference of thigh (10cm above patella)	36	35
Circumference of knee joint	36	36
Circumference of calf (around the area with the highest volume)	31.5	31.5
Circumference of ankle (Around lateral and medial malleoli)	27.5	27.5

Table 3.13: Circumferences of the lower extremities – Anthropometry – Final kinesiological analysis

3.8.5 Goniometry

The reference values for ranges of motion (ROM) used in this section were the average values suggested by Kendall et al. (20). The active ranges of motion (AROM) and passive ranges of motion (PROM) were measured in angular degrees (°) with a plastic universal goniometer and recorded using the International Sagittal-Frontal-Transverse-Rotation (S.F.T.R) Method according to Gerhardt & Russe (43). Measurement procedures suggested by Norkin & White (31) were employed. Adduction, internal rotation, and external rotation of the right hip joint were not measured, as recommended by UNIFY ČR (48).

(xxx = Not tested; F90 = In 90° flexion)

	Left lower extremity		Right lower extremity		
	AROM	PROM	AROM	PROM	Reference values
	Hip joint				
S	5-0-90	5-0-100	5-0-75	5-0-85	10-0-125
F	30-0-10	35-0-10	20-0-xxx	25-0-xxx	45-0-10
R (F90)	20-0-10	25-0-10	xxx-0-xxx	xxx-0-xxx	45-0-45
	Knee joint				
S	0-0-110	0-0-125	0-0-xxx	0-0-xxx	0-0-140
	Ankle joint				
S	10-0-30	15-0-40	10-0-30	10-0-40	20-0-45
R	15-0-30	15-0-30	15-0-30	15-0-30	20-0-40

Table 3.14: Goniometry – Final kinesiological analysis

3.8.6 Muscle strength testing

The classification system of muscle strength introduced by Janda (17) was used. This system classifies muscle strength into 6 levels, *Grade 0* to *Grade 5*.

Grade 5: A normal, very strong muscle with a full range of movement and is able to overcome considerable resistance.

Grade 4: A muscle with good strength and a full range of movement, and is able to overcome moderate resistance.

Grade 3: A muscle with a complete range of movement against gravity only when resistance is not applied.

Grade 2: A very weak muscle with a complete range of motion only when gravity is eliminated by careful positioning of the patient.

Grade 1: A muscle with evidence of slight contractility but no effective movement.

Grade 0: A muscle with no evidence of contractility.

The muscle strength tests were performed with adaptations to the actual condition of the patient. Abduction and adduction of the left hip joint were performed when the patient was in the supine position as he was not able to lie on his right side. Adductors of the right hip were not tested as a full range of adduction was contraindicated.

(xxx = Not tested)

Movements performed	Primary muscles involved	Left lower extremity	Right lower extremity
	Hip joint		
Flexion	Iliopsoas	4	3
Extension	Gluteus maximus Biceps femoris (long head) Semimembranosus Semitendinosus	3	3

Adduction	Adductor magnus Adductor longus Adductor brevis Gracilis Pectineus	4	xxx
Abduction	Gluteus medius Gluteus minimus Tensor fasciae latae	4	3
	Knee joint		
Flexion	Biceps femoris Semimembranosus Semitendinosus	4	3
Extension	Quadriceps femoris	4	4
	Ankle joint		
Plantar flexion	Triceps surae	4	4
Plantar flexion with flexed knee	Soleus	4	4
Inversion with dorsal flexion	Tibialis anterior	4	4
Inversion with plantar flexion	Tibialis posterior	4	4
Eversion with plantar flexion	Peroneus longus Peroneus brevis	4	4

Table 3.15: Muscle strength testing – Final kinesiological analysis

3.8.7 Muscle length testing

Test procedures and grading system according to Janda (16) were used.

(xxx = Not tested)

Muscles	Left lower extremity	Right lower extremity
Gastrocnemius	0	0
Soleus	0	0
Iliopsoas	xxx	0
Rectus femoris	xxx	0
Hamstrings	0	1
Hip adductors (Pectineus, adductor brevis, adductor magnus, adductor longus, semitendinosus, semimembranosus, and biceps femoris)	1	2

Table 3.16: Muscle length testing – Final kinesiological analysis

3.8.8 Soft tissue examination

Test procedures according to Lewit (24) were used. The examination was focused on the lower extremities and the pelvic region.

Skin and subcutaneous tissues:

It was generally dry. Psoriatic patches could be seen and were especially pronounced over the knee joints. All sutures, sterile dressings, and elastic bandages had been removed. No varices or hematomas observed. A 20-cm surgical scar on the lateral aspect of the right hip could be seen. Slight redness but no edema around the scar. No local increase in temperature. No scar hypertrophy. Increased resistance in the ventro-dorsal direction could be felt when the scar was examined with fingertips.

Fascia:

A rotational approach around the longitudinal axis of the examined segments was used. Increased resistance could be felt around the hip and knee joints on the right leg, and ankle joints on both sides.

Muscle palpation:

No pain was experienced by the patient upon palpation

Muscles	Left lower extremity	Right lower extremity
Iliacus	Normal	Normal
Psoas major	Normal	Normal
Rectus femoris	Normal	Normal
Gluteus maximus	Normal	Slightly hypotonic
Hamstrings	Hypotonic	Hypotonic
Hip adductors	Normal	Hypertonic
Piriformis	Normal	Hypertonic
Triceps surae	Normal	Normal

Table 3.17: Muscle palpation – Soft tissue examination – Final kinesiological analysis

3.8.9 Joint examination

Joint play techniques according to Lewit (24) were used.

Joints	Left lower extremity	Right lower extremity
Patella (Latero-laterally and cranio-caudally)	Normal	Normal
Knee joint (Latero-laterally)	Normal	Slight restriction in both medio-lateral and latero-medial directions
Tibiofibular joint (Medio-dorsally and latero-ventrally)	Normal	Normal
Talocrural joint (Dorsal push)	Normal	Normal
Tarsometatarsal/Lisfranc joint (Dorsal push)	Normal	Normal
Transverse tarsal/Chopart joint (Dorsal push)	Normal	Normal
Metatarsophalangeal (MTP) joint (Dorso-plantarly)	All restricted in all direction, especially for the 1st MTP joint	All restricted in all direction, especially for the 1st MTP joint
Proximal interphalangeal (PIP) joint of foot (Dorso-plantarly and latero-laterally)	All restricted, especially in the latero-lateral directions	All restricted, especially in the latero-lateral directions
Distal interphalangeal (DIP) joint of foot (Dorso-plantarly and latero-laterally)	All restricted, especially in the latero-lateral directions	All restricted, especially in the latero-lateral directions

Table 3.18: Joint examination – Final kinesiological analysis

3.8.10 Neurological examination

Deep tendon reflexes in the lower extremities:

Reflexes	Left lower extremity	Right lower extremity
Patellar reflex	Normal	Normal
Achilles reflex	Normal	Normal
Medioplantar reflex	Normal	Normal

Table 3.19: Deep tendon reflexes in the lower extremities – Neurological examination – Final kinesiological analysis

Deep (proprioceptive) sensation in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Sense of joint position	Normal	Normal
Sense of movement of body segments	Normal	Normal

Table 3.20: Deep (proprioceptive) sensation in the lower extremities – Neurological examination – Final kinesiological analysis

Superficial (exteroceptive) sensation in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Tactile sensation	Normal	Normal

Table 3.21: Superficial (exteroceptive) sensation in the lower extremities – Neurological examination – Final kinesiological analysis

Cortical sensory functions in the lower extremities:

Examination procedures according to Bigley (7) were used.

Senses	Left lower extremity	Right lower extremity
Graphesthesia	Normal	Normal
2-point discrimination	Normal	Normal
Touch localization (Superomedial thigh, medial knee, medial ankle, mid-dorsum, lateral ankle)	Normal	Normal

Table 3.22: Cortical sensory functions in the lower extremities – Neurological examination – Final kinesiological analysis

3.8.11 Screening for deep vein thrombosis (DVT)

Homan's sign was absent.

3.8.12 Conclusion of the final kinesiological analysis

The patient's weight slightly dropped but he still had a normal BMI. He was oriented and cooperative. All sutures, sterile dressings, and compression stockings had been removed.

The patient was suffering from pain in the right hip during movements and it was 1-2 on VAS. He claimed to be able to eat, dress up, and go to the toilet alone with 2 forearm crutches.

The patient was able to stand alone on flat ground with the help of 2 forearm crutches. The right lower extremity could not yet be weight-bearing. Bilateral hallux valgus was seen. Right leg in flexion. Visible hamstrings hypotrophy in the lower extremities. Pelvis elevated on the left side. Trunk slightly rotating towards the right side. Slightly increased thoracic kyphosis. Shoulders protracted. Head in slight lateroflexion towards the left side and in slight protrusion. He had an abdominal breathing stereotype.

The patient was instructed to use the 3-point gait during walking, with complete relief of weight on the right leg. He kept the right knee and hip in slight flexion during gait. The pace of gait and stride length were moderate. Gait rhythm was regular. The patient was able to have the whole left foot flat on the floor before propelling the body with the forefoot. Left hip was in external rotation. Sufficient left hip extension during gait. Shoulders and head protracted. The patient had a tendency of looking down to the floor during gait. The patient was able to walk up and down the stairs correctly with the crutches.

Anatomical length of the whole right LE, functional lengths of the whole right LE, and length of the right thigh were all one centimeter greater compared to the left side. Circumferences of the left thigh were bigger.

The ROM of the right hip was limited by the slight pain the patient was suffering. Active hip flexion reached 75 degrees and 85 passively. Both active and passive hip extension reached 5 degrees. Active hip abduction was 20 and 25 passively. Left hip had significantly limited ranges of rotation. ROM of the ankle joints were not ideal.

Muscles of the right hip and knee were generally weak. Strength of right hip flexors, extensors, abductors, and right knee flexors was at grade 3. Left hip extensors also at grade 3. Right knee extensors at grade 4. Strength of muscles for ankle movements were symmetrical (grade 4) on both sides.

The right hamstrings and the left hip adductors were slightly shortened. The right hip adductors were greatly shortened.

A 20-cm surgical scar on the lateral aspect of the right hip could be seen. Slight redness but no edema around the scar. No local increase in temperature. No scar hypertrophy. Increased resistance in the ventro-dorsal direction could be felt when the scar was examined with fingertips. Fasciae around the right hip and knee joints, as well as the ankle joints on both sides, showed some slight restriction. Right hip adductors and

piriformis were hypertonic. Right gluteus maximus was slightly hypotonic. Bilateral hamstrings were hypotonic.

On the left side, the tarsometatarsal, MTP, PIP, and DIP joints were all restricted. On the right side, the knee, MTP, PIP, and DIP joints were restricted.

The results of neurological examination did not show any abnormalities.

Homan's test had a negative result.

3.9 Evaluation of therapeutic effects

This section includes some noticeable changes that I found in the patient during the final kinesiological analysis. The level of pain on VAS reported by the patient during hip movements dropped from 5-6 when asked during the initial kinesiological analysis to 1-2 during the final kinesiological analysis.

3.9.1 Static posture

Before therapy	After therapy
Left knee and hip semi-flexed.	No semi-flexion.
Trunk was slightly bending and rotating to the right side	Trunk still slightly rotating but not bending
Shoulders elevated and protracted with the crutches.	Shoulders protracted but not elevated.

Table 3.23: Static posture – Evaluation of therapy effects

3.9.2 Gait

Before therapy	After therapy
Slow pace of gait.	Increased.
Short stride length.	Increased
Mainly kept contact with the floor with the left forefoot.	Could kept the heel in more contact with the floor between steps.
Minimal hip extension	Increased.
Trunk in hyperkyphosis.	Was able to stay more upright.
Could walk 50 meters before break.	Could walk 150 meters before break.
Could not use the stairs with crutches correctly.	The patient understood the principles of stairs-climbing with crutches.

Table 3.24: Gait – Evaluation of therapy effects

3.9.3 Dimensions of the lower extremities

No changes in all the lengths of the lower extremities.

Before therapy	After therapy
Circumference of right thigh (15cm above patella) was 34cm	37cm (Increased by 3 cm).
Circumference of right thigh (10cm above patella) was 33cm	35cm (Increased by 2 cm).
Circumference of the right knee joint was 37cm	36cm (Decreased by 1 cm).

Table 3.25: Dimensions of the lower extremities – Evaluation of therapy effects

3.9.4 Ranges of motion of the lower extremities

Left lower extremity	Before therapy (AROM / PROM)	After therapy (AROM / PROM)
Hip abduction	25 / 25	30 / 35
Ankle dorsal flexion	5 / 10	10 / 15

Table 3.26: Left LE – ROM of the lower extremities – Evaluation of therapy effects

Right lower extremity	Before therapy (AROM / PROM)	After therapy (AROM / PROM)
Hip flexion	60 / 75	75 / 85
Hip extension	0 / 0	5 / 5
Hip abduction	10 / 10	20 / 25
Ankle plantar flexion	30 / 40	30 / 40
Ankle dorsal flexion	5 / 10	10 / 10

Table 3.27: Right LE – ROM of the lower extremities – Evaluation of therapy effects

Right hip flexion increased by 15 degrees actively and 10 degrees passively which is significant. Both active and passive extension of the right hip showed a 5-degree increase. Hip abduction increased by 10 degrees actively and 15 degrees passively which is also significant. Ankle dorsal flexion increased by 5 degrees actively.

3.9.4 Muscle strength of the lower extremities

Muscle strength of the left lower extremity was maintained with any changes.

Right lower extremity	Before therapy	After therapy
Hip flexion	2	3
Hip extension	1	3
Hip abduction	2	3
Knee extension	2	4

Table 3.28: Right LE – Muscle strength of the lower extremities – Evaluation of therapy effects

The strength of the right hip flexors and abductors improved by 1 grade point, and 2 points for hip extensors. The strength of the right knee extensors also improved by 2 grade points. The muscle strengthening exercise were quite effective in making the muscles of the right lower extremity generally stronger.

3.9.5 Muscle length of the lower extremities

The length of the left hip adductors improved by 1 grade point from grade 2 to grade 1. It changed from being “greatly shortened” to “slightly shortened”. Passive stretching was effective in this case.

Right lower extremity	Before therapy	After therapy
Iliopsoas	1	0
Rectus femoris	1	0
Hamstrings	2	1
Hip adductors	2	2

Table 3.29: Right LE – Muscle length of the lower extremities – Evaluation of therapy effects

The right iliopsoas and rectus femoris became “not shortened” after therapy, and the length of the right hamstrings increased and became “slightly shortened” only, which indicates that the passive stretching for these muscles was effective. The ROM of right hip adduction improved but the hip adductors were still “greatly shortened” according to the grading system.

3.9.6 Soft tissue quality in the lower extremities

The edema and slight increase in local temperature around the surgical scar found before therapy had faded away after therapy. The increased resistance in all directions away from the sterile dressing might have been caused by the sterile dressing itself. After its removal, only ventro-caudal resistance could be felt when the scar was directly examined.

After therapy, there was no increase in resistance in the fasciae around the left knee and hip joints even though no specific soft tissue techniques directed to this problem were applied.

Left lower extremity	Before therapy	After therapy
Gluteus maximus	Hypotonic	Normal
Hamstrings	Hypotonic	Hypotonic
Hip adductors	Hypertonic	Normal

Table 3.30: Left LE – Soft tissue quality in the lower extremities – Evaluation of therapy effects

PIR and RI were effective for relaxing the left hip adductors.

Right lower extremity	Before therapy	After therapy
Gluteus maximus	Hypotonic	Slightly hypotonic
Hamstrings	Hypotonic	Hypotonic
Hip adductors	Hypertonic	Hypertonic
Iliacus	Hypertonic	Normal
Psoas major	Hypertonic	Normal
Rectus femoris	Hypertonic	Normal
Piriformis	Hypertonic	Hypertonic

Table 3.31: Right LE – Soft tissue quality in the lower extremities – Evaluation of therapy effects

The tonicity of the right gluteus maximus slightly improved. PIR and RI were not effective for relaxing the right hip adductors, but were effective for the right iliacus, psoas major, and rectus femoris.

3.9.7 Joint mobility

Only a few joint restrictions were treated due to time constraints. The MTP, PIP, and DIP joints on both sides were not treated and they were therefore restricted during the both the initial and final kinesiological analyses. The restrictions in the bilateral Lisfranc joints and the right patella were removed successfully with mobilization techniques according to Lewit (24). However, the restriction found in the right knee joint persisted.

3.9.8 Conclusion of evaluation

Comparing the condition of the patient before and after therapy, the most important changes were that he could walk for a much longer distance and that he successfully learnt to use the stairs. The strength of the muscles responsible for the right hip and knee muscles showed a substantial increase. The tonicity of the right iliopsoas and rectus femoris reduced significantly. The pain suffered by the patient was also reduced significantly.

The most influential therapeutic procedures used probably the strengthening exercises for the right knee and hip extensors, which became notably stronger during testing. The PIR and RI techniques used for relaxing the right iliopsoas and rectus femoris were also notably favorable in a way that the tonicity of those muscles reduced considerably after the application during each therapy session. However, I would maintain that the relaxation techniques were not as successful as the strengthening exercises because the relaxation effects did not last long after therapy, which is also the reason why the PIR and RI techniques were used on the same muscles every day.

During the practice, no physical therapy modalities were employed, even though certain methods might have been useful. An example is that heat therapy might have been used for improving circulation and reducing the edema as well as the pain. This is because, firstly, the patient did not have a prescription for physical therapy, and secondly, I did not have access to the equipment for physical therapy as the department which was

responsible for applying physical therapy was totally separated from where I was mainly meeting the patients at.

Instead of using proprioceptive neuromuscular facilitation (PNF), which is useful for both muscle strengthening, stretching, and relaxation, basic analytical strengthening and relaxation techniques were used for the following reasons:

1. An integral part of PNF is rotation, which makes the PNF patterns spiral. However, rotation also made PNF unsuitable for the patient right LE as it was a contraindicated motion for patient after THR and his implants had not even been cemented yet.

2. Rotation which makes the PNF patterns spiral and diagonal is important for the stretch and resistance in PNF. Effective stretch and resistance permit irradiation. Without this irradiation, PNF may just end up like any basic analytical methods. And given that the rotational component is crucial for effective resistance (2), the PNF strengthening techniques would not work as well without it.

3. There are certain PNF patterns for the pelvis, but the primary muscles they work on are the muscles in the waist area which are not what I wanted to treat.

4. Resisted neck extension patterns in the prone position, for instance, was also considered. It could have been used to provoke irradiation into hip extension and abduction (2). Unfortunate, this technique was not used as well because the PNF course at the Faculty did not cover the neck patterns before the clinical placement started, and I personally had no practical experience with them.

5. The complicatedness of PNF and its communication requirement are probably the major reasons why I did not use choose to use PNF at all. The patient was senile, and sometimes he needed to take more time to understand something. If we had tried PNF, he might have just ended up being overwhelmed with all

the verbal commands. Moreover, if I wanted to give the patients some verbal commands, I as a non-Czech speaker would need my supervisor at the Institute to translate the commands for the patient. This might disturb the normal timing in PNF which is also a crucial for the optimal efficacy.

6. PNF was not used for the upper extremities either. This is because the exercises I taught him to do were much simpler, yet the treatment goal could still be achieved. The performance of those exercises also did not require my presence, which made them suitable to be used as autotherapy as well.

4 CONCLUSION

Undertaking the clinical placement at the Institute of Rheumatology and writing this bachelor's thesis have deepened my knowledge of the human hip joint, hip osteoarthritis and its treatment strategies, and the rehabilitation care before and after a total hip replacement. I am absolutely delighted to see the improvements in the physical state of the patient after all the therapy sessions. The aim of this thesis has been achieved.

Once again, I would like to thank all my teachers, instructors, and patients for all the support, patience, and cooperation they have offered. It has been a truly educational and inspiring experience for me.

5 REFERENCES

1. The abbreviations used are listed on pages 6 to 8.

2. ADLER, S.S., D. BECKERS, and M. BUCK. *PNF in Practice: An Illustrated Guide*. 4th ed., revised. Berlin: Springer, 2014. ISBN 978-3-642-34987-4.

3. AFFATATO, S. *Perspectives in Total Hip Arthroplasty: Advances in Biomaterials and their Tribological Interactions*. Amsterdam: Woodhead Publishing, 2014. ISBN 978-1-78242-031-6.

4. ALTMAN, R. et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. *Arthritis & Rheumatism*. 1991, vol. 34, iss. 5, pp. 505-514.

5. BARNSLEY, L., L. BARNSLEY, and R. PAGE. Are Hip Precautions Necessary Post Total Hip Arthroplasty?. A systematic review. *Geriatric Orthopaedic Surgery & Rehabilitation*. 2015, vol. 6, iss. 3, pp. 230-235.

6. BENNELL, K.L. et al. Effect of Physical Therapy on Pain and Function in Patients with Hip Osteoarthritis. *JAMA*. 2014, vol. 311, iss. 19, pp. 1987-1997.

7. BIGLEY, G.K. Sensation. In: WALKER, H.K., W.D. HALL, and J.W. HURST, eds. *Clinical Methods: The History, Physical, and Laboratory Examinations*. 3rd ed. Boston: Butterworths, 1990. ISBN: 0-409-90077-X.

8. CABRERA, J.A. and A.L. CABRERA. Total Hip Replacement. In: FRONTERA, W.R., J.K. SILVER, and T.D. RIZZO JR, eds. *Essentials of Physical Medicine and Rehabilitation: Musculoskeletal Disorders, Pain, and Rehabilitation*. 3rd ed. Philadelphia: Saunders, 2015. ISBN 978-1-4557-7577-4.

9. DAGENAIS, S., S. GARBEDIAN, and E.K. WAI. Systematic Review of the Prevalence of Radiographic Primary Hip Osteoarthritis. *Clinical Orthopaedics and Related Research*. 2009, vol. 467, iss. 3, pp. 623-637.

10. DRUMMOND, A. et al. Hip Precautions following Primary Total Hip Replacement: A National Survey of Current Occupational Therapy Practice. *British Journal of Occupational Therapy*. 2012, vol. 75, iss. 4, pp. 164-170.

11. GOLD COAST HEALTH. *Total Hip Replacement: Pre and post-operative patient guide* [online]. n.d. [viewed 1 March 2019]. Available from: https://www.goldcoast.health.qld.gov.au/sites/default/files/THR%20Patient%20Guide.pdf

12. GRAY, P.A. and E. PRATT. Total Hip Arthroplasty. In: MAXEY, L. and J. MAGNUSSON, eds. *Rehabilitation for the Postsurgical Orthopedic Patient*. 3rd ed. St. Louis: Mosby, 2013. ISBN 978-0-323-07747-7.

13. HAMILL, J., K.M. KNUTZEN, and T.R. DERRICK. *Biomechanical Basis of Human Movement*. 4th ed. Philadelphia: Wolters Kluwer Health, 2015. ISBN 978-1-4511-7730-5.

14. HANSEN, J.T. *Netter's Clinical Anatomy*. 4th ed. Philadelphia: Elsevier, 2019. ISBN 978-0-323-53188-7.

15. IYER, K.M. The Adult Hip and Its Disorders. In: IYER, K.M., ed. *The Hip Joint*. Singapore: Pan Stanford, 2017. ISBN 978-981-4745-14-7

16. JANDA, V. *Funkční Svalový Test*. Praha: Grada, 1996. ISBN 80-7169-208-5.

17. JANDA, V. *Muscle Function Testing*. London: Butterworths, 1983. ISBN 0-407-00201-4.

18. JIANG L. et al. The relationship between body mass index and hip osteoarthritis: A systematic review and meta-analysis. *Joint Bone Spine*. 2011, vol. 78, iss. 2, pp. 150-155.

19. KAPANDJI, A.I. *The Physiology of the Joints*. 5th ed. Vol. 2. Edinburgh: Churchill Livingstone, 2011. ISBN 978 0 7020-3942-3.

20. KENDALL, F.P. et al. *Muscles: Testing and Function with Posture and Pain*. 5th ed. Baltimore: Lippincott Williams & Wilkins, 2005. ISBN 0-7817-4780-5.

21. KNUDSON, D. *Fundamentals of Biomechanics*. 2nd ed. New York: Springer, 2007. ISBN 978-0-387-49311-4.

22. KOHN, M.D., A.A. SASSOON, and N.D. FERNANDO. Classifications in Brief: Kellgren-Lawrence Classification of Osteoarthritis. *Clinical Orthopaedics and Related Research*. 2016, vol. 474, iss. 8, pp. 1886-1893.

23. LESPASIO, M.J. et al. Hip Osteoarthritis: A Primer. *The Permanente Journal*. 2018, vol. 22, iss. 1, 17-084.

24. LEWIT, K. *Manipulative Therapy: Musculoskeletal Medicine*. Edinburgh: Churchill Livingstone, 2010. ISBN 978-0-7020-3056-7.

25. MACGREGOR, A.J. et al. The Genetic Contribution to Radiographic Hip Osteoarthritis in Women: Results of a Classic Twin Study. *Arthritis & Rheumatism*. 2000, vol. 43, iss. 11, pp.2410-2416.

26. MOORE, K.L., A.F. DALLEY, and A.M.R AGUR. *Clinically Oriented Anatomy*. 7th ed. Baltimore: Wolters Kluwer Health, 2014. ISBN 978-1-4511-1945-9.

27. MORETTI, V.M. and Z.D. POST. Surgical Approaches for Total Hip Arthroplasty. *Indian Journal of Orthopaedics*. 2017, vol. 51, iss. 4, pp. 368-376.

28. MURPHY, N.J., J.P. EYLES, and D.J. HUNTER. Hip Osteoarthritis: Etiopathogenesis and Implications for Management. *Advances in Therapy*. 2016, vol. 33, iss. 11, pp.1921-1946.

29. NEUMANN, D.A. *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation*. 2nd ed. St Louis: Mosby, 2010. ISBN 978-0-323-03989-5.

30. NICE. *Osteoarthritis: care and management* [online]. February 2014 [viewed 1 March 2019]. Available from: https://www.nice.org.uk/guidance/cg177

31. NORKIN, C.C. and D.J. WHITE. *Measurement of Joint Motion: A Guide to Goniometry*. 5th ed. Philadelphia: F.A. Davis, 2016. ISBN 9780803645660.

32. OATIS, C.A. *Kinesiology: The Mechanics and Pathomechanics of Human Movement*. 3rd ed. Philadelphia: Wolters Kluwer, 2017. ISBN 9781451191561.

33. OUTERBRIDGE, R.E. The Etiology of Chondromalacia Patellae. *The Journal of Bones and Joint Surgery. British volume*. 1961, vol. 43-B, iss. 4, pp. 752-757.

34. PALAN, J. and A. MANKTELOW. Surgical approaches for primary hip replacement. *Orthopaedics and Trauma*. 2018, vol. 32, iss. 1, pp. 1-12.

35. PALASTANGA, N. and R. SOAMES. *Anatomy and Human Movement: Structure and Function*. 6th ed. Edinburgh: Churchill Livingstone, 2012. ISBN 978-0-7020-3553-1.

36. PETIS, S. et al. Surgical approach in primary total hip arthroplasty: anatomy, technique and clinical outcomes. *Canadian Journal of Surgery*. 2015, vol. 58, iss. 2, pp. 128-139.

37. PULIDO, L. and W.J. HOZACK. Surgical Principles of Total Hip Arthroplasty. In: PARVIZI, J. and B. KLATT, eds. *Essentials in Total Hip Arthroplasty*. Thorofare: SLACK Incorporated, 2013. ISBN 978-1-55642-870-8.

38. RACGP. *Guideline for the management of knee and hip osteoarthritis*. 2nd ed. East Melbourne: RACGP, 2018. ISBN 978-0-86906-500-6.

39. REIJMAN, M. et al. Validity and reliability of three definitions of hip osteoarthritis: cross sectional and longitudinal approach. *Annals of the Rheumatic Diseases*. 2004, vol. 63, iss. 11, pp. 1427-1433.

40. RESTREPO, C. et al. Hip Dislocation: Are Hip Precautions Necessary in Anterior Approaches?. *Clinical Orthopaedics and Related Research*. 2011, vol. 469, iss. 2, pp. 417-422.

41. REYES, C. et al. Association Between Overweight and Obesity and Risk of Clinically Diagnosed Knee, Hip, and Hand Osteoarthritis: A Population-Based Cohort Study. *Arthritis & Rheumatology*. 2016, vol. 68, iss. 8, pp.1869-1875.

42. ROYAL NATIONAL ORTHOPAEDIC HOSPITAL. *A patient's guide to Hip Precautions Following Primary or Revision Total Hip Replacement* [online]. Middlesex: Royal National Orthopaedic Hospital, January 2018 [viewed 1 March 2019]. Available from: https://www.rnoh.nhs.uk/sites/default/files/patient/j000283_-_18-20_rnoh_pg_hip_precautions_booklet_web_release-aut13-nid2822.pdf

43. RUSSE O.A. and J.J. GERHARDT. *International SFTR Method of Measuring and Recording Joint Motion*. Bern: Hans Huber, 1975. ISBN 3-456-80075-4.

44. SALTER D.M. and T. AIGNER. Pathogenesis and pathology of osteoarthritis. In: HOCHBERG, M.C. et al., eds. *Rheumatology*. 7th ed. Philadelphia: Elsevier, 2019. ISBN 978-0-7020-6865-2.

45. SHARMA, L., D. KAPOOR, and S. ISSA. Epidemiology of osteoarthritis: an update. *Current Opinion in Rheumatology*. 2006, vol. 18, iss. 2, pp. 147-156.

46. SNELL, R.S. *Clinical Anatomy by Regions*. 9th ed. Baltimore: Wolters Kluwer Health, 2012. ISBN 978-1-60913-446-4.

47. SULSKY, S.I. et al. Epidemiological Evidence for Work Load as a Risk Factor for Osteoarthritis of the Hip: A Systematic Review. *PLoS ONE*. 2012, vol. 7, iss. 2, e31521.

48. UNIFY ČR. 4.1.6 FYZIO/6 - Totální endoprotéza kyčelního kloubu. In: *Standardy léčebných postupů a kvalita ve zdravotní péči* [online]. Praha: Verlag Dashöfer, 2015 [viewed 1 March 2019]. ISSN 2336-4580. Available from: http://www.unify-cr.cz/obrazky-soubory/4-1-6-rtf-8d5c8.pdf?redir

49. VOTAVOVÁ, M. and V. CIKÁNKOVÁ. Rehabilitation Following Arthroplasty. In: KOLÁŘ, P. *Clinical Rehabilitation*. Praha: Alena Kobesová, 2013. ISBN 978-80-905438-0-5.

50. WHO. *International Statistical Classification of Diseases and Related Health Problems: 10th revision*. 5th ed., revised. Geneva: World Health Organization, 2016. ISBN 978-92-4-154916-5.

51. WIELAND, H.A. et al. Osteoarthritis — an untreatable disease?. *Nature Reviews Drug Discovery*. 2005, vol. 4, pp.331-344.

52. GASKELL, L. Musculoskeletal assessment. In: PORTER, S.B., ed. *Tidy's Physiotherapy*. 15th ed. Edinburgh: Churchill Livingstone, 2013. ISBN 9780702043444.

53. MASON, D. Exercise in rehabilitation. In: PORTER, S.B., ed. *Tidy's Physiotherapy*. 15th ed. Edinburgh: Churchill Livingstone, 2013. ISBN 9780702043444.

Appendix 1 — Ethical Approval

CHARLES UNIVERSITY
FACULTY OF PHYSICAL EDUCATION AND SPORT
José Martího 31, 162 52 Prague 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: Rehabilitation after Total Hip Replacement

Project form: Bachelor's Thesis

Period of realization of the project: February 2019

Applicant: Wong Steven Chun Tak, Department of Physiotherapy, UK FTVS

Main researcher: Wong Steven Chun Tak, Department of Physiotherapy, UK FTVS

Workplace: Revmatologický ústav, Na Slupi 4, 128 50 Praha 2

Supervisor: PhDr. Tereza Nováková, Ph.D., Department of Physiotherapy, UK FTVS

Project description: The thesis is expected to be composed of a theoretical part and a case study of a patient who underwent a right total hip replacement due to psoriatic arthritis. The theoretical part will be based on available relevant literature, while the case study will consist of details concerning the medical history of the patient, an initial kinesiological examination, therapy applied, and a final kinesiological examination. No invasive procedures will be performed.
Characteristics of participants in the research: Only one male patient at the age of 71 will participate in the case study. The patient recently underwent a total hip replacement due to osteoarthrosis.
Ensuring safety within the research: Certain examination or therapeutic procedures to be used may cause pain, damage to the surgical wound, or even dislocation of the joint. A physiotherapist employed by the Institute of Rheumatology will be present during the examination and therapy session to ensure the quality and safety of the procedures performed. He should be professionally competent to practice physiotherapy according to the Czech regulations. No invasive procedures will be performed. Risks of therapy and methods will not be higher than the commonly anticipated risks for this type of therapy.
Ethical aspects of the research: The participating patient will be a male adult who is not suffering from any mental conditions. This study may help to better understand the condition suffered by the patient and to identify the procedures which may be beneficial for the condition.
Personal data protection the gained data will be processed and safely retained in an anonymised form and published in a bachelor thesis, possibly also in journals, monographs, and presented at conferences, possibly also used in further research at UK FTVS. After the anonymization the personal data will be deleted.
Taking photographs/videos of the participants anonymisation of persons on the photographs will be done by blurring their faces or parts of the body or characteristics that could lead to identification of the person. Non-anonymised photographs will be deleted after the end of the research.
I shall ensure to the maximum extent possible that the research data will not be misused
Informed Consent: Attached

It is the 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. 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, 7.2.2019 Applicant's signature Wong Chun Tak

Approval of UK FTVS Ethics Committee

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

The research project was approved by UK FTVS Ethics Committee under the registration number: 076/2019

Date of approval: 13.2.2019

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
Jose Martího 31, 162 52, Praha 6

Stamp of UK FTVS

Signature of the Chair of
UK FTVS Ethics Committee

– 20 –

Appendix 2 — Sample Informed Consent Form

UNIVERZITA KARLOVA
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: .....

Jméno a příjmení zákonného zástupce .....

Vztah zákonného zástupce k pacientovi ..... Podpis: .....

Appendix 3 — List of Tables