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Rehabilitation Plan and Process to Treat a Patient with Chronic Lower Back Pain

Bachelor's Thesis

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Abstract

This bachelor thesis deals with the medical rehabilitation of chronic lower back pain. It aims to process the knowledge from the theoretical part and utilize it to provide effective rehabilitation. It is divided into two parts namely the theory and case study.

The theory part is further divided into a general and special part. The general theory deals with the anatomy, physiology, and pathophysiology of the lumbar spine. The anatomy describes the structure of vertebrae as well as the soft tissue that surrounds the lumbar spine. It also explains the importance of the connection of the spine to the pelvis and provides information about the biomechanics of the spine including its mobility and stability. It then moves on to describe pathological situations that can result in lower back pain and effective treatment for these situations whether it is conservative or invasive. There is a strong link between chronic lower back pain and psychology, it also impacts the individual socially and this bachelor thesis confronts the topic of the prognosis of the diagnosis and its prevention.

The special part focuses on different methods of rehabilitation and physiotherapy methods that are used to treat chronic lower back pain in a conservative manner. A combination of kinesiotherapy, manual techniques and therapeutic modalities if effective during rehabilitation.

The final part of this bachelor thesis includes a case study of a 78-year-old male who was treated at St Anne's Hospital Inpatient Rehabilitation Department in Brno for Lumboischiadal Syndrome. This practical part includes the initial kinesiological examination of the patient and describes the procedures used for the short-term rehabilitation plan. The results of 12 days of rehabilitation by the author are given and a long-term rehabilitation plan is discussed.

Results: the goals set in the short-term plan were met successfully and the patient left the department with an overall improved musculoskeletal situation. The patients pain drastically decreased and there was an improvement in his symptoms allowing him to return home and complete his daily activities with more ease.

Abstrakt

Tato bakalářská práce pojednává o léčebné rehabilitaci u chronických bolestí zad. Cílem bylo zpracovat poznatky teoretické části a využít je k poskytnutí účinné rehabilitace. Práce se dělí na dvě části – teoretickou a kazuistiku.

Teoretická část je dále rozdělena na obecnou a speciální část. Obecná část se zabývá anatomií, fyziologií a patofyziologií bederní páteře. Anatomie popisuje strukturu obratlů i měkkých tkání v okolí bederní páteře. Také vysvětluje význam spojení páteře a pánve a poskytuje informace o biomechanice páteře, včetně její pohyblivosti a stability. Dále popisuje patologické stavy, které vedou k bolesti dolní části zad, účinnou léčbu těchto stavů, až už konzervativní nebo invazivní. Existuje významná souvislost mezi bolestí dolní části zad a psychologií, dále též zmiňuje vlivy sociální, a bakalářská práce dále rozvádí téma prognózy a prevence tohoto onemocnění.

Speciální část práce se zabývá různými metodami rehabilitace a fyzioterapie, které se využívají v konzervativní léčbě chronické bolesti dolní části zad. Rehabilitace je efektivní v případě užití kombinace kinezioterapie, manuálních technik a fyzikální léčby.

Poslední část bakalářské práce zahrnuje kazuistiku 78letého muže, který byl hospitalizován na lůžkovém rehabilitačním oddělení Fakultní nemocnice u sv. Anny v Brně pro lumboischialgický syndrom. Praktická část zahrnuje vstupní kineziologické vyšetření pacienta a popisuje fyzioterapeutické metody využité během krátkodobého rehabilitačního plánu. Je popsán výsledek dvanáctidenní rehabilitace autorem a je navržen dlouhodobý rehabilitační plan.

Výsledky: cíle krátkodobého rehabilitačního plánu byly úspěšně naplněny a pacient opouštěl oddělení v celkově lepším stavu pohybové soustavy. Došlo k významnému snížení pacientovy bolesti a další příznaků, což mu umožní vykonávat denní aktivity s výrazně menšími obtížemi.

Declaration

I hereby declare that this thesis with title **Rehabilitation Plan and Process to Treat a Patient with Chronic Lower Back Pain** I submit for assessment is entirely my own work and has not been taken from the work of others save to the extent that such work has been cited and acknowledged within the text of my thesis.

Brno March 31, 2023

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Francesca Gina Evans

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Glossary

AB	–	Abdominal Bracing
ABD	–	Abduction
ADD	–	Adduction
ADL	–	Activities of Daily Living
AH	–	Abdominal Hollowing
ASIS	–	Anterior Superior Iliac Spine
CLBP	–	Chronic Lower Back Pain
Cm	–	Centimetre
CT	–	Computed Tomography
IAP	–	Intra-Abdominal Pressure
IVD	–	Intervertebral Disc
Kg	–	Kilogram
LBP	–	Low/Lower Back Pain
LS	–	Lumbosacral
MRI	–	Magnetic Resonance Imaging
NSAID	–	Non-Steroidal Anti-Inflammatory Drug
PIR	–	Post Isometric Relaxation
PNF	–	Proprioceptive Neuromuscular Facilitation
PIIS	–	Posterior Inferior Iliac Spine
PSIS	–	Posterior Superior Iliac Spine
ROM	–	Range Of Motion
SI	–	Sacroiliac
TLF	–	Thoracolumbar Fascia
TFL	–	Tensor Fascia Latae
VAS	–	Visual Analogue Scale

1 Review of Theoretical Knowledge

1.1 GENERAL PART

1.1.1 Definition of chronic lower back pain

"Low back pain is pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without sciatica, and is defined as chronic when it persists for 12 weeks or more. Nonspecific low back pain is pain not attributed to a recognizable pathology (infection, tumour, osteoporosis, rheumatoid arthritis, fracture, inflammation)."[1]

According to the National Institute of Neurological Disease and Stroke, chronic back pain is pain that continues for 12 weeks or longer, even after an initial injury or underlying cause of back pain has been treated. It impairs function and affects the quality of life of those suffering from it. Chronic pain is a malfunctioning of the pain system and the experience of chronic pain is associated with multi-network activation in the Central Nervous System(CNS) resulting in it comprising multiple components, including sensory, emotional, cognitive, and behavioural elements. [2] [3]

Sciatica refers to pain that radiates along the sciatic nerve and is a descriptive term rather than a diagnosis. It is typically felt in the buttocks, down the back of the leg, and possibly to the foot. Sciatica is most commonly a consequence of common conditions including lumbar spinal stenosis and disc pathologies like a herniated disc or degenerative disc disease. The term sciatica is used because it describes the radiculopathy that occurs when one or more of the nerves that make up the large sciatic nerve are irritated or pinched. Sciatica usually resolves with time and conservative treatment. However, some sciatica symptoms such as progressive weakness, loss of leg sensation and incontinence may indicate a potentially serious injury to the sciatic nerve and surgery may be warranted. [4]

The character of pain can be described depending on the localization of the symptoms. Symptoms are grouped under the heading's lumbago, backache and sciatica. These terms are used as follows:

- *Lumbago*: a sudden attack of severe low back pain, causing some degree of fixation and twinges on attempted movement.
- *Backache*: discomfort in the lower back.
- *Sciatica*: pain that radiates strictly from the buttock to the posterior thigh and calf. It is restricted to a specific dermatome (L4, L5, S1 or S2) and may be accompanied by paraesthesia and motor and/or sensory deficit. In practice, however, the term is used inaccurately if pain and paraesthesia are felt in the anterior part of the thigh and/or lower leg (L2–L3).

1.1.2 Incidence and prevalence

"More than 70 percent of persons in developed countries will experience low back pain at some time in their lives. Each year, between 15 and 45 percent of adults have low back pain, and 5 percent of persons present to the hospital with a new episode. About 10 percent remained unable to work and about 20 percent had persistent symptoms at one year."[1]

"Low back pain (LBP) is the leading cause of years lived in disability in high-income and middle-income countries. Moreover, a similar increase has also been seen in low-income countries. In 2015, LBP was responsible for approximately 60.1 million years lived in disabilities, an increase of 54% since 1990. For industrialized countries, LBP is a very costly illness and indirect costs (work absenteeism, productivity loss) account for more than half of the total costs. In many patients, the specific nociceptive source of LBP cannot be identified and those affected are often classified as having so-called "nonspecific low back pain." Nonspecific LBP represents 90% to 95% of cases, with other causes being specific spinal pathology (<1% of cases) and radicular syndrome (approximately 5%–10% of cases). The global point prevalence of activity-limiting LBP lasting more than 1 day is estimated to be 12%. Although most patients with acute LBP show rapid improvements in pain and disability within 1 month, between 4% and 25% of patients drift to chronicity. The prevalence of chronic low back pain (CLBP) increases linearly from the third decade of life until the age of 60 years, with CLBP being more prevalent in women."[5]

1.1.3 Anatomy of the lumbar spine

1.1.3.1 The vertebral column

As a whole, the spinal skeleton consists of 5 parts:

- The cervical vertebrae (C1-7)
- Thoracic vertebrae (T1-12)
- Lumbar vertebrae (L1-5)
- Sacrum (S1-5)
- Coccyx

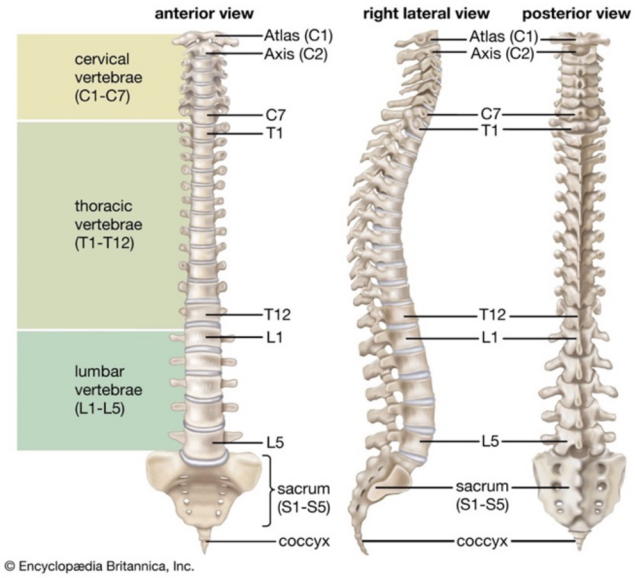

Figure 1: Structure of the vertebral column [6]

The lower back comprises of the lumbar spine, which is formed by vertebral bones, intervertebral discs, nerves, muscles, ligaments, and blood vessels.

The lumbar spine starts at the end of the 12th thoracic vertebrae, contains 5 vertebrae (L1-5), and then ends at the start of the 5 sacral vertebrae (S1). The lumbar vertebrae progressively increase in size going down the lower back. The vertebrae are connected with joints at the back to enable bending and twisting movements of the spine. The spinal cord ends at the beginning of the lumbar spine at level L1-2 and is called the conus medullaris, and the remaining nerve roots, called the cauda equina, descend down the remainder of the spinal canal. The vertebrae protect the cauda equina by enclosing these tissues within a bony canal. [6]

1.1.3.2 Structure of the lumbar vertebra

Anatomically, the lumbar vertebrae are larger and thicker block shaped bones. Each vertebra consists of a large, cylindrical vertebral body anteriorly, with a bony ring or "neural arch" posteriorly. The vertebral bodies, together with the intervertebral discs, provide the length of the lumbar spine and sustain most of the compressive loading. The neural arch forms a protective bony ring around the neural elements of the lumbar region while providing numerous bony projections or processes that serve to form the surfaces of the facet joints or act as sites of attachment for spinal muscles and ligaments. The neural arch, along with the intervertebral discs, sustains most of the torsional load bearing acting on the lumbar spine.[7] The lumbar vertebrae are mostly similar in structure but there are some exceptions. The important parts and their differences are described below.

Vertebral body

The major load-bearing structure of the lumbar spine is the vertebral body, situated in front. The lumbar vertebral bodies have the following features:

- L1 and L2 have a smaller height in front compared to the back
- L3 has an equal height in the front and at the back
- L4 and L5 have a taller height in front compared to the back

The vertebral bone is resistant to bending and contains cavities that allow blood vessels to grow into the vertebral body for nourishment. [6]

Vertebral pedicle

A pedicle is a short section of thick and rounded bone that connects the vertebral body to the vertebral arch at the back. The pedicles also help transfer loads from the vertebral body to the vertebral arch. [6]

Vertebral arch

The back of the vertebra contains a bony vertebral arch with an open central space. The vertebral arch has the following components**:**

- Laminae. The pedicles continue behind the vertebral body to form the laminae which are thin bony plates and for the major portion of the vertebral arch. The laminae decrease in height from L1 to L5. The laminae protect access to the spinal cord.
- Spinous process. At the mid-point of the vertebral arch, a bony protrusion called the spinous process projects backward and downward. This process can be felt while touching the lower back and serves as an attachment for various muscles of the spine.
- Transverse process. On either side of the spinous process, there are bony protrusions called the transverse processes. Similar to the spinous process, these also serve as attachment points for spinal muscles.
- Vertebral foramen. The hollow space inside the vertebral arch is the vertebral foramen. When the vertebrae are stacked, this space forms the spinal canal. [6]

The lumbar spinal canal houses and protects the spinal cord (down to the L2 vertebra) and cauda equina (downward after L2). The vertebrae are connected to each other through facet joints and a network of ligaments.[6]

1.1.3.3 Lumbar vertebral joints

Vertebral joint complexes are important parts of the spine that enable spinal motion. Several structures form one joint complex, which consists of two vertebral bodies separated by an intervertebral disc together with their facet joints.

The joint that is formed from two adjacent vertebral bodies together with the layer of cartilage on each body and the intervertebral disc between them is known as

the symphyseal joint. These joints together allow for the mobility of the vertebral column. The facet joints from the superior vertebral body connect with the facet joints from the inferior vertebral body. The facet joints are important spinal mobilizers to all movement between adjacent vertebrae but are also spinal stabilizers that carry loads to prevent excessive motion (particularly retroversion and rotation). They not only allow movement but more importantly determine the direction of movement.

Facet joints are true synovial joints formed from the superior and inferior articular process that project off the pedicle and lamina. They are also called zygapophysial joints. The articular processes are each covered with hyaline cartilage and there is synovial fluid inside the joints capsule to allow joint gliding. The facet joints from the superior vertebral body connect with the facet joints from the inferior vertebral body. The facet joints are important spinal mobilizers to all movement between adjacent vertebrae but are also spinal stabilizers to prevent excessive motion. They not only allow movement but more importantly determine the direction of movement. [6,8]

1.1.3.4 Lumbar ligaments

We can find multiple ligaments in the lumbar area that limit excess motion thereby protecting the spinal cord. These ligaments also allow for smooth motion and act to absorb loads during trauma. They are interconnected with fascia, tendons of muscles and the outer membrane of the intervertebral discs. The ligaments are classified into 3 groups: extrasegmental, segmental and regional. Extrasegmental ligaments include the anterior and posterior longitudinal ligaments as they extend through the length of the spine. The interspinous, supraspinous, transverse and flavum ligaments are segmental as they only connect two adjacent vertebrae. The iliolumbar ligament is unique to the lumbar segment so it is a regional ligament. The ligamentum flavum is the thickest and 80% of its composition is elastin fibres allowing it to stretch to 40% of its resting length without injury. It is important for spinal stability and maintains the upright position as it is in tension even in the anatomical position. This puts pressure on the intervertebral discs and creates prestress. The ligaments elasticity decrease with age. [9,10]

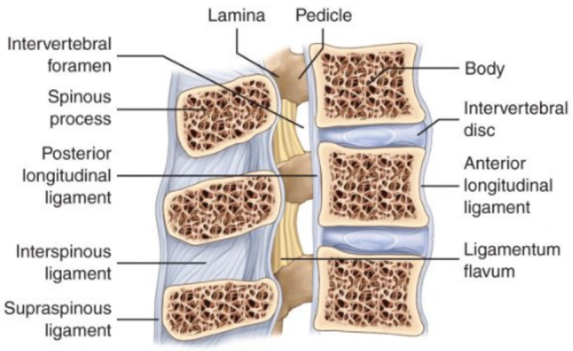

Figure 2: Ligaments of the lumbar spine[11]

Important ligaments of the lumbar spine can be seen in the table below:

Table 1: Ligaments of the Lumbar Spine

Ligament	Connections	Function
Anterior Longitudinal	Connects the anterior surfaces of the vertebrae	Stabilizes the spine during extension
Posterior Longitudinal	Connects the posterior surfaces of the vertebrae	Stabilizes the spine during flexion
Flavum	Short-paired ligaments that connect the vertebral arches of adjacent vertebrae	Cover and protect the spinal cord posteriorly
Supraspinous and Interspinous	Connect the spinous processes of adjacent vertebrae	Limit flexion
Intertransverse	Connects the transverse processes	Limits lateroflexion
Iliolumbar	Fan-like ligaments connecting L5 to Iliac bone	Stabilize lumbosacral spine

1.1.3.5 Muscles

There is a large and complex group of muscles that work together to support the spine, help hold the body upright and allow the trunk of the body to move, twist and bend in many directions.

The muscles of the back can be divided into heterochtonous muscles and autochtonous muscles.

- Heterochtonous muscles developed originally on the anterior side of the trunk and moved to the back. These are extrinsic muscles that are innervated by the anterior branches of the spinal nerves.
- Autochtonous muscles developed on the back itself and are intrinsic muscles. They are innervated by the posterior branches of the spinal nerves.

Intrinsic muscles are the muscles of the body that occur near the axial and appendicular skeleton deep within the body. The extrinsic muscles occur superficially.[10]

Muscles specific to the lumbar region:

Table 2: Muscles Specific to the Lumbar Region

Muscle Group	Anatomy	Function
Extensors (Attached to the posterior aspect of the spine)	**Erector spinae:** This is the lower back's largest and most powerful muscle group. It consists of three distinct muscles (iliocostalis, longissimus, and spinalis) that run the length of the spine superficially.	Hold the upright position. Enable standing and lifting of objects. Involved in spinal extension/hyperextension, lateral flexion and rotation to the rear.
	Multifidus: Attach the posterior spines of adjacent vertebrae, these muscles are not palpable.	Affect local segments of the spine as they only span a few joints. Provide extensor torque at specific joints.
Flexors (Attached to the anterior aspect of the spine)	**The intrinsic group** is formed from the psoas major, psoas minor and the iliacus.	Flex the trunk and depress the ribs.
	The extrinsic group of muscles is the abdominal wall muscles namely the rectus abdominis, internal and external obliques and the transverse abdominis.	Unilateral flexion of the rectus abdominis causes lateral flexion to the ipsilateral side. The transverse abdominis functions to stabilize the spine through increasing intra-abdominal pressure. The oblique muscles assist with flexion but are not the main flexors.
Lateral flexors and rotators	**The internal and external oblique muscles** are found on the lateral side of the abdomen.	Contralateral trunk rotation
	The quadratus lumborum is a deep and flat sheet of muscle on either side of the posterior abdomen.	Pure lateral flexion

The spinal stabilization system is the core stabilization of our body and is attributed to a muscle complex called the Deep Stabilizing System of the Spine (DSSS). The Deep Spinal stabilization includes the multifidus, deep neck flexors, diaphragm, abdominal wall and pelvic floor muscles. These muscles are automatically activated prior to movement and a stable base is generated. In proper stabilization, activity does not involve only one muscle but the whole chain working together. [11]

1.1.3.6 Fascia

The lumbodorsal fascia extends from the sacrum and iliac crests to the lower thoracic vertebrae. It consists of an anterior, middle and posterior layer in order to separate the muscles in this region into compartments. It plays an important role in the lower back as it serves as an attachment site for many muscles and connects the hip, pelvic, lumbar and thoracic joint systems. It serves to maintain the stability of the lumbosacral area and is responsible for the transfer of loads between the trunk and the extremities. The transverse abdominis provides anticipatory stabilization of the lumbosacral region by increasing the intraabdominal pressure and thereby tenses the thoracolumbar fascia. [12,13]

Fascia is a connective tissue that is richly innervated with sensory nerve fibres therefore the lumbodorsal fascia has been proposed as one of the reasons for chronic lower back pain. The nociceptive free nerve endings within the lumbodorsal fascia can become irritated or inflamed due to injury or overuse and can undergo morphological changes in chronic pain situations. [12,13]

1.1.3.7 Lumbar intervertebral discs

Intervertebral discs are avascular structures that are composed of three main parts: the innermost layer is the soft nucleus pulposus which is surrounded by concentric fibres of the annulus fibrosus. The discs are kept in place by the fibrous endplates of the superior and inferior vertebrae as well as the anterior and posterior longitudinal ligaments. Discs are integral to the joint complex and function to bear the axial load and absorb and distribute shock during movement.[14]

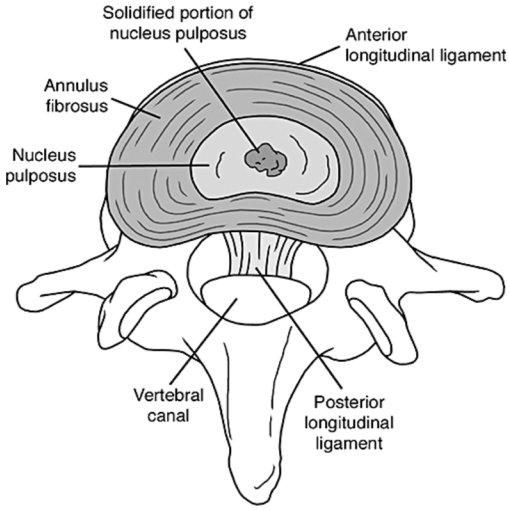

Figure 3: Lumbar intervertebral discs[15]

The lumbar intervertebral discs have a wedge shape and are approximately cylindrical. The wedge shape contributes to the normal lordosis found in the lumbar spine. The cross-sectional area of the lumbar discs is the largest of the spine due to the increased load that the lumbar spine needs to bear. This increased ratio of vertebral body height to disc height also causes increases the range of motion in the lumbar spine.[15]

1.1.3.8 Nerves

The spinal cord ends between the first and second lumbar vertebrae (L1-L2). The end of the spinal cord is called the cauda equina and is a collection of the roots of the lumbar and sacral spinal nerves.

The lumbar plexus is a network of peripheral nerve fibres formed by the anterior branches of the first four lumbar nerves. The plexus is located in front of the transverse processes of the lumbar vertebra within the psoas major muscle. It supplies the skin and muscles of the lower extremities, together with the sacral plexus. The nerves arising from the lumbar plexus from superior to inferior are iliohypogastric, ilioinguinal, genitofemoral, lateral femoral cutaneous, femoral nerve, obturator, and nerve to the lumbosacral trunk.

The sacral plexus is formed by the lumbosacral trunk and the sacral nerves. It is located anterior to the piriformis muscle on the posterior pelvic wall. The sacral plexus produces the sciatic nerve (from L4 to S3) which is the largest branch of the sacral plexus and the longest nerve in the body. Injury or pressure on the sciatic nerve causes sciatica. It also gives rise to the posterior femoral nerve (S1 to S3), superior gluteal nerve (L4 to S2), and inferior gluteal nerve. [16–18]

1.1.3.9 Lumbar Blood Vessels

The blood supply to the lumbar spine is facilitated through branches of the large abdominal aorta, which descends the front of the lumbar vertebral bodies. There are 4 or 5 lumbar arteries which branch off the abdominal aorta and are paired branches that course in a posterolateral direction along the lumbar vertebra. The lumbar arteries are responsible for sending blood to the vertebral bodies, intervertebral discs and joints as well as the surrounding back muscles, fascia and ligaments. [19]

Accompanying each lumbar artery is a lumbar vein that lies superiorly to its adjacent artery. The lumbar veins carry deoxygenated blood from the lumbar structures back to the heart and run along the inside of the posterior abdominal wall. The first and second lumbar veins drain into the subcostal vein via the ascending lumbar vein. The third and fourth lumbar veins drain into the inferior vena cava.[20]

1.1.4 Relation of the lumbar spine to the pelvis – the lumbosacral region and lumbopelvic stability system

The lumbar spine is connected to the pelvis via the sacroiliac joints. The pelvis connects the lower extremity to the trunk and without this connection, the upright position of the body would not be possible. The co-ordinated movement of the pelvis-hip-spine connection allows for the maintenance of the balance of the trunk and hip. The mobility of the connections allows for the co-ordination of movement during postural changes. The hip is influenced by the lower 3 lumbar vertebrae. If stiffness occurs in one part of the mobile segment, there needs to be accommodation in another part which consequently causes hypermobility. Motion between the spine and pelvis is called spinopelvic mobility. If there are abnormal motions, it will result in an unbalanced spine and pelvis. A decreased tilt of the pelvis during movement occurs with stiffness of the spine.[21]

Various components contribute to lumbopelvic stability including bone and ligament structures of the spine and pelvis, muscle compression forces and nervous system control. This arrangement transfers weight from the upper body through the lumbosacral spine and across the pelvis to the femoral heads. The abdominal, pelvic floor and multifidus muscles work synergistically to influence posture by the intra-abdominal pressure regulation and thoracolumbar fascial tension. The nervous system determines the level of stability that is required by evaluating the present status of the lumbo-pelvic region and provides strategies for achieving the correct stability.

The inferior border of the abdominopelvic cavity is formed by the pelvic floor and provides support for the abdominopelvic organs, it is therefore the only transverse load-bearing muscle group in the body. The pelvic muscles, including the deep abdominal and back muscles, along with the pelvic floor muscles, provide a foundation of support for the lumbar spine by using an anticipatory mechanism to stabilize the trunk and control intraabdominal pressure. These muscles work together to distribute forces evenly throughout the lumbar spine and pelvis, helping to maintain proper alignment and prevent excessive movement or rotation. The pelvic floor muscles function as a unit to increase the intrabdominal pressure during functional tasks like lifting or coughing and to prevent incontinence.[22]

If there is dysfunction in the pelvic floor muscles, the muscles in the lumbar spine do not receive appropriate support. This can cause compensations in movement patterns, such as increased lumbar spine extension or anterior pelvic tilt, which can put increased stress on the lumbar spine and lead to pain or injury. Pain can refer upwards or downwards from the pelvic muscles if they are working inefficiently.[23]

1.1.5 Kinesiology of spine

1.1.5.1 Curvature of the lumbar spine

The spinal column has four natural curves namely - the cervical, thoracic, lumbar and sacral curves. The first three curves are mobile curves and the last sacral curve is fixed. The lumbar spine, together with the cervical spine has a lordotic curve. The curves of the spine help with shock absorption and work together with the intervertebral discs to distribute any stresses placed on the spine. If one of the curves is increased or decreased then the statics of the body will be affected as the balance of the upright body is also reliant on the curves.

Transitional zones occur between two curves and the vertebrae within these zones have unique characteristics. The vertebrae are characterized by combined anatomical morphology retained from two adjacent regions of the spine. The thoracolumbar and lumbosacral junction transition zones involve the lumbar spine. They are biomechanically weak structures and can therefore be areas of pain.

When the lordotic curve of the lumbar region is excessive, hyperlordosis occurs. This is not a favourable situation as it is found combined with an anterior tilt of the pelvis. It creates a swayback posture which puts excessive pressure on the facet joints and the posterior area of the discs resulting in irritation and pain. Alternatively, if there is hypolordosis then a flatback posture occurs with a subsequent posterior tilt of the pelvis.

1.1.5.2 Spinal stability

Spinal stability is defined as the ability of the spinal structures to maintain cohesion when the spine is placed under physiologic loads. Displacement needs to be limited when different physiologic positions are performed so that damage to the spinal cord and column does not occur. When there is a loss of stability and spinal instability occurs, it is a pathological process, and the vertebra are displaced outside of their normal physiologic range. White and Punjabi describe spinal stability using the concept of neutral zones. “The neutral zone (NZ) is a region of intervertebral motion around the neutral posture where little resistance is offered by the passive spinal column.” If injury occurs, the size of the neutral zone increases which can cause spinal instability. It is important for the spine to be flexible to allow for easy movement but it additionally needs to be stiff and rigid especially when there are extra forces acting on the spine. The rigidity protects the neural elements and maintains the anatomic relationships between the vertebrae. The basis of spinal stability is that the flexibility and rigidity occur simultaneously. Punjabi's model of stability consists of three subsystems – the joints and soft tissue form the passive subsystem, the active subsystem is formed by the muscles and neural conduction makes up the neural subsystem. Spinal stability is initiated

upon activation of the neural subsystem when the receptor organs located in joints, muscles, and ligaments detect a change in movement. The neural subsystem then determines the necessary muscular activation and sends efferent signals to the required muscles to ensure postural control and movement. Coordination and integration of these three subsystems produces a balanced response that allows the spinal column to function correctly and safely.[22, 21,25]

1.1.5.3 Spinal mobility

In the absence of fixation, the range of gross lumbar motion is primarily determined by the sum of individual intervertebral disc resistance to distortion, the thickness of the discs, and the angle and size of the articular surfaces. As in other regions of the spine, the movements of the lumbar spine are flexion, extension, lateral bending, and rotation. While lumbar motion is potentially greater than that of the thoracic spine because of the lack of rib restriction, facet facing and heavy ligaments check the range of rotatory motion.[26]

Motion occurring at the lumbar spine is critical to a person's ability to perform the numerous tasks of daily living. When considering the lumbar spine as an entire unit, motions traditionally are described using cardinal planes as a reference. This system is quite useful as a classification of joint displacement, as it provides a conceptual framework for lumbar ROM by creating common reference points. It is important to note, however, that under the conditions of loading associated with daily activities, the lumbar spine is nearly always undergoing multidirectional displacement. In fact, at the level of the joint surface, pure single-plane movement may not exist.

When determining the nature of gross motions of the lumbar spine, the plane of the facet joints dictates the directions of displacement possible. For example, the sagittal plane alignment of the lumbar facet joints favours flexion and extension but greatly limits rotation. The height of the IVD acts to maintain the alignment of the joint surfaces as well as tension on the segmental ligaments. The vertical dimension of the IVD space also is related to the available motion at a given motion segment, since the deformation of the disc contributes to the motion between adjacent vertebrae. In the lumbar spine, the normal disc spaces are larger than those of the thoracic spine. This contributes to the relatively large arc of motion that is possible in the lumbar spine. With disc space narrowing such as occurs with disc degeneration, changes in the positional relationships of the vertebrae to one another can adversely affect joint mechanics.

Lumbar Flexion

Lumbar flexion is the forward bending of the spine. It is achieved by flattening the lumbar lordosis. During flexion the upper lumbar segments move into flexion first followed

by the middle then lower segments. A critical concept related to lumbar flexion is its relationship to anterior pelvic tilting, a phenomenon often referred to as lumbopelvic rhythm. Initially, the trunk inclines forward as the lumbar lordosis flattens. Once full lumbar flexion is achieved, the additional forward inclination of the trunk occurs from the pelvis tilting anteriorly upon the hip joints. The forward rotation of the trunk is in turn typically limited by tension in the hamstring muscles. Thus, a person's ability to touch his or her toes relies upon pelvic rotation and extensible hamstring muscles, as well as the ROM of lumbar flexion. Lumbar flexion is limited by tension in the posterior annulus fibrosus and the posterior ligament system.[8]

Lumbar Extension

Lumbar extension is the backward bending causing an increase in the lumbar lordosis. The overall magnitude of lumbar extension is much less than that of lumbar flexion because of the unique bony anatomy of the lumbar vertebrae. As the lumbar spine extends from a normal lordosis, the spinous processes approach one another, and tension in the anterior longitudinal ligament restricts motion. The amount of pelvic displacement is also limited compared to during flexion. During extension, the regions of T11-L2 and L4-S1 are most strained. In a pathological situation with inextensible hip flexors, it causes the pelvis to be held in anterior rotation causing a permanent increased lumbar lordosis. This results in an increased load placed on the posterior elements of the lumbar spine and can be associated with symptoms and tissue degeneration.[8,27]

Lumbar Rotation and Lateroflexion

There is minimal rotation seen in the lumbar spine however when side bending occurs, there is a lateral rotation of the spinous processes. Rotation of the spine is compensated by achieving a larger rotation of the trunk and neck. Excessive lumbar rotation can be a risk to the intervertebral discs.

The joint surfaces in the lumbar spine limit the possibility of rotation here, although a rotation of up to 5 degrees can be found in some individuals. This is due to the articulating surfaces on the right and left sides not being part of a common rotation surface. Because of the roughly sagittal plane alignment of the facet joints, the transverse plane motion of rotation is quite restricted in the lumbar spine, limited by the approximation of the facet joint surfaces. Anatomically, the facet joints surface at L5–S1 tend to have a more oblique arrangement than the other segments of the lumbar spine. Because of this, authors have proposed that more lumbar rotation occurs at this segment than in the other segments of the lumbar spine.

Lumbar side-bending, which is a displacement in the frontal plane, has a larger ROM than rotation but substantially less than the sagittal plane motions. The

amplitude of motion appears relatively evenly distributed over all segments except L5–S1, which is quite restricted by bony anatomy and tension from the iliolumbar ligament. Side-bending cannot occur without some lumbar rotation (and vice versa) because of the phenomenon known as joint coupling. Joint coupling occurs when two motions are linked together so that one cannot occur without the other.[8,27]

1.1.6 Types of pathologies of the spine

Chronic lower back pain can be due to many reasons – structural, functional, referred or even psychologic. Due to the aim of this thesis, I will highlight a few important facts about the most important pathologies, focusing specifically on the ones that physiotherapy has the most influence on and relating to the case study found in the second part of this paper.

1.1.6.1 Structural pathology of the lumbar spine

Structural pathologies can be divided into congenital or acquired and are a modification of the number or shape of the lumbar vertebrae.

- **Hemivertebrae**

Hemivertebra is a congenital condition in which only one half of the vertebral body develops and is a common cause of congenital scoliosis.

Each vertebra has two lateral ossification centres where bone develops and then hardens. If one of these centres doesn't function properly and fails to develop, a hemivertebra can occur. Due to one side of the vertebra being underdeveloped, the shape of the vertebra is like a wedge. This disrupts the normal spinal configuration and can cause an excessive lateral curvature. [28]

- **Lumbar Structural Scoliosis**

Scoliosis refers to an abnormal lateral curvature of the spine and is considered structural when the curve is inflexible due to a change in the bony structures of the vertebra. Spinal curves in the sagittal plane are normal but if they exist in the frontal plane, it is considered abnormal as the spine should be straight in the frontal plane. When scoliosis is present in the lumbar region it appears as a 'C' shaped curve and can appear independently or with an 'S' shaped thoracic scoliosis. If it is present from birth it is known as congenital scoliosis.

Scoliosis can also occur due to degeneration and the curve here is relatively minor. Another form of scoliosis is the functional type. As the L5 sits on top of the sacrum, the position of the pelvis has a high influence on the position of the lumbar spine.

- **Lumbarization S1**

Lumbarization of S1 occurs when there is a failure of the first sacral vertebra to fuse with the rest of the sacrum. Due to this, it appears that there are six lumbar vertebrae and only four sacral vertebrae. The first sacral vertebra is said to be 'lumbarized' and is free to move with the rest of the lumbar spine resulting in 6 mobile lumbar vertebrae.

Lumbarization of the spine can lead to certain clinical symptoms that can limit a patient's movement and cause pain. Patients often experience pain during movement which causes difficulty while performing activities of daily living. [29,30]

- **Sacralization L5**

Sacralization occurs when there is fusion of the L5 vertebra to the pelvis causing one less lumbar vertebra. It can either be fused to the sacrum below, or to the iliac bone at each side of the pelvis or both. If L5 is fused to the sacrum then it is termed central sacralisation, and if it is fused to the sides of the iliac bone it is can be uni- or bi- lateral transverse sacralisation.[31]

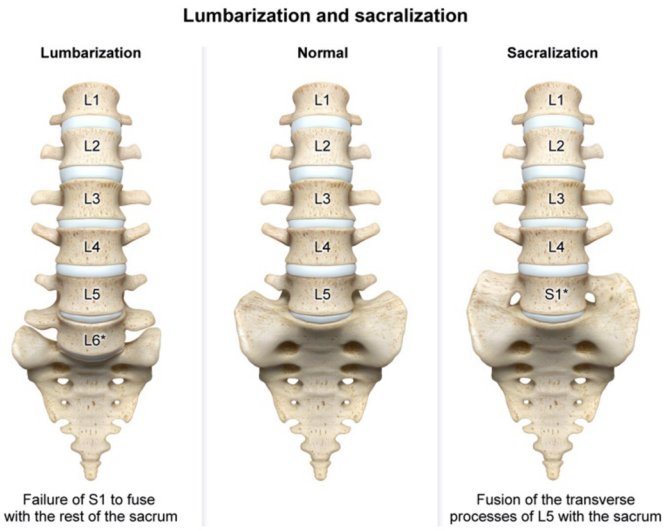

Figure 4: Lumbarization and Sacralization[32]

- **Spinal Lumbar Stenosis**

Congenital lumbar spinal stenosis is a developmental narrowing of the spinal canal, which is associated with early neurogenic complications and relatively few radiographically evident degenerative spondylotic changes. Due to the narrowed canal these people can experience degenerative or arthritic problems earlier in life. [32,33]

Spinal stenosis causes a decreased ratio between the size of the canal and the neurovascular bundle and so there is a compression of the nerves that travel through the lumbar plexus. Lumbar flexion typically provides comfort compared to extension as it increases the vertebral foramina and so decreasing the compression on the nerves. Congenital lumbar stenosis is less common than stenosis occurring due to the degeneration processes linked with aging.[7]

Spinal stenosis can also be acquired and in this case, it is usually a slowly progressive disorder. As aging occurs, the vertebral discs lose their hydration, become less spongy and decrease in height. The disc is now harder and so some of the disc can bulge into the spinal canal, causing stenosis. Other causing factors are ligament thickening, the formation of bony spurs and degenerative spondylolisthesis and scoliosis. [34]

Symptoms are not always felt and can be caused by compression of the nerves, inflammation, or both.

– **Spina Bifida, Meningocele, Meningomyelocele**

Spina bifida is a type of neural tube defect and occurs when the spinal cord and canal do not develop properly. The neural tube is the embryonic precursor to the central nervous system, and it develops into the baby's brain and spinal cord. The aetiology of spina bifida is unknown but an important risk factor is insufficient folic acid in the early stages of pregnancy. [35]

- **Spondylolysis And Spondylolisthesis**

Both spondylosis and spondylolisthesis are conditions that affect the facet joints. Excessive or repetitive lumbar extension or rotation can cause degeneration as well as failure in the facet joint area.

Spondylosis occurs when there is a defect in the facet joint resulting in a weakness which causes a stress fracture. There is a disconnection between the vertebral body and the arch.

Spondylolisthesis is a result of the vertebra slipping anteriorly or posteriorly onto the vertebra below. Lumbar ventrolisthesis most commonly occurs at the level of L5-S1, it can occur at L4-L5 but rarely at a higher level. It can be a uni- or bi- lateral anterior slippage depending on the pars interarticularis disconnection being on one side of the spine or both. Spondylolisthesis can occur due to bilateral spondylosis, but it can also be a result of degenerative changes (disc or joint deterioration) that cause the vertebra to slip out of place. Bone of the facet joints actually grows back and overgrows, causing an uneven and unstable surface area, which makes the vertebrae less able to stay in place.[36,37, 38]

Lumbar retrolisthesis is defined as the slippage of vertebra backward on one another. It most commonly occurs at L4-L5 in adults and can create symptoms of leg and back pain. [39]

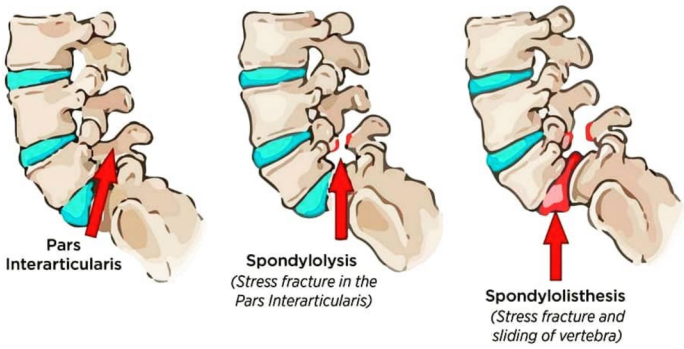

Figure 5: Spondylosis and Spondylolisthesis [40]

- **Traumas**

Fractures of the upper lumbar, lower thoracic spine and thoracolumbar junction occur commonly, and the severity of the fractures varies widely. They can result from high energy-trauma like a vehicle accident and these types of fractures usually require emergency care and can be associated with fractures of other regions like the pelvis or limbs. Pathological fractures can also occur during lower impact events, such as a minor fall in older persons, those with osteoporosis as the bones are weaker or due to bone tumours.

Lumbar fractures can be classified according to the American Academy of Orthopaedic Surgeons based on their pattern of injury:

- Compression fractures occur due to the flexion pattern and is a failure of the anterior column to resist compression from a vertical direction.
- Distraction or chance fractures occur because the posterior column fails to resist compression and often occur due to the seatbelt in car accidents.
- Rotational fractures are less common and occur due to excessive side bending.[40,41]

- **Autoagressive disorders**

<u>Spondylarthritis</u>

Spondylarthritis is a group of diseases that cause inflammation of the spine and joints.

Ankylosing spondylitis (Bechterew's disease) is a type of spondylarthritis. It is a chronic inflammatory rheumatic disease where the body attacks its own immune system. It primarily affects the thoracic and lumbar spine and the sacroiliac joints but can spread to other parts of the body. The pain is characterized as inflammatory back pain

which causes the patient to wake in the second half of the night with intense pain and experience morning stiffness that is improved with movement. There is a decreased range of motion in the spine and in advanced stages of the disease the vertebra can fuse resulting in a "bamboo spine".[42]

- **Tumours**

Spinal tumours are most commonly secondary musculoskeletal tumours as a result of the metastases of visceral organ cancers. The vertebral column is the most common site for bone metastases. This is mostly seen in older patients. Primary musculoskeletal system sarcomas involving the spinal column are rare. Tumour-like lesions or non-cancerous benign tumours can also occur in the spine and are most commonly seen in younger patients. These tumours compromise the vertebral canal and can cause instability. Spine tumours only account for a small percentage of reasons for back pain.[43]

- **Metabolic disorders**

Osteoporosis is a bone disease that causes the bones to become weaker and lose their strength. It develops when bone mineral density and bone mass decrease and changes the structure and strength of bone. It is most often seen in post-menopausal women and elderly people, and it is often asymptomatic. Due to the loss of bone strength, osteoporosis is usually diagnosed when a minor fall or normal bone stress results in a fracture.[44]

- **Degenerative diseases**

Degeneration is a normal part of ageing due to the forces that are placed on the joints over time, but this process can sometimes be disproportional. If the level of deterioration is higher than what would be considered normal for a specific age or if it impairs function, then it can be considered osteoarthritis. Osteoarthritis of the spine refers to inflammation and degeneration of the facet joints specifically.[45]

- **Disc Pathologies**

Pathological conditions of discs in the lumbar spine are frequent. The symptoms vary and can be more or less serious in different situations. Disc degeneration and herniation are two types of pathologies and are both mostly due to the wear and tear that occurs because of aging. The water content of the discs is higher in younger people and this decreases with age. The hydration of discs is important to keep them flexible and sturdy.

Lumbar disc degeneration

Degeneration of the discs involves a decrease in the height of the disc and can also be termed disc thinning. This process occurs with aging and usually occurs in middle-aged or older persons. The nucleus pulposus is responsible for the height of the disc and so this is the part of the disc that loses its height. As a result, the space between two lumbar vertebrae decreases and subsequently the size of the intervertebral foramina decreases causing compression of the spinal nerves that pass through the foramina. Thinner discs also cause a decrease in the range of motion as disc height is proportional to the degree of motion possible.

Lumbar disc herniation

Lumbar disc herniation happens when the outer layer, the annulus fibrosus, becomes weakened. The process of disc herniation starts when the inner nucleus pulposus pushes against the outer fibrous ring.

There are 3 stages of herniation:

1) Disc bulge – this happens as the annular fibres weaken and allow the nucleus pulposus to push against them resulting in a bulging of the disc.
2) Disc rupture/herniation – the pressure against the annulus fibrosus causes a tear and allows some of the nucleus pulposus to push through.
3) Sequestered disc – this is the most serious stage as part of the nucleus pulposus moves through the ruptured annulus fibrosus and separates from the disc.

Pathological discs can cause compression of the nerves and sciatica can occur when there is compression of the *n. ischiadicus*.[46]

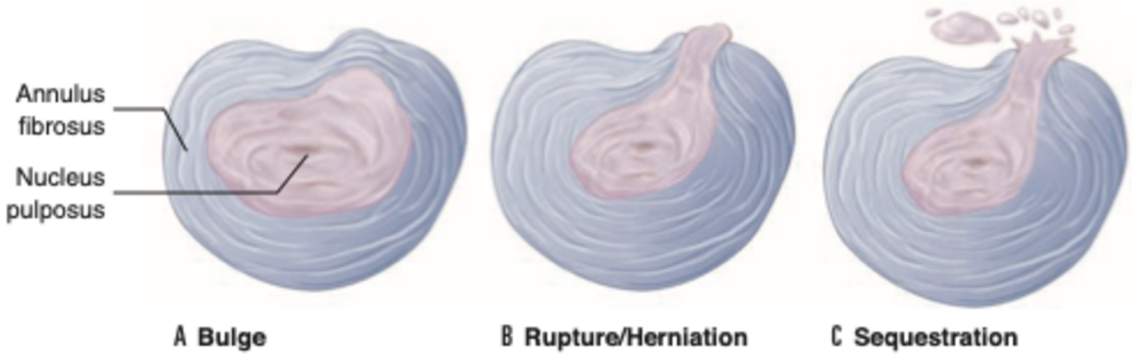

Figure 6: The phases of disc herniation [47]

- **Failed Back Surgery Syndrome**

Failed back surgery syndrome refers to the condition that occurs with patients who have had unsuccessful back surgery. These patients experience new or persisting symptoms of pain and muscle spasms. The pain can reduce post-surgery and then worsen after a few months due to the build-up of scar tissue around spinal nerve roots. [48]

1.1.6.2 Functional pathology of the lumbar spine

Functional pathology deals with problems of the soft tissues instead of the structure of the vertebrae and can be classified as non-specific pain. If a functional pathology occurs, it is usually in combination with other musculoskeletal pathologies as we can see a knock-on effect of one pathology affecting another.

- **Hypertonic musculature**

Hypertonic muscles are usually present with all other musculoskeletal conditions. When certain muscles are hypertonic, it will result in muscular imbalances. Muscles have spindle fibres that act as receptors to detect a change in the muscle's composition. When the muscle is stretched too far and too quickly it activates the protective mechanism of the spindle's stretch reflex. This causes the muscle to contract which can result in spasm. The sensitivity of their setting is determined by the gamma motor system of the brain, which can order them to contract and tighten or allow them to be relaxed and loose. Tighter muscles are less tolerant to stretch as the spindles are more sensitive. Causes of globally tight muscles can be muscle overuse, adaptive shortening of muscles, muscle splinting and overstretching.[47]

- **Myofascial pain syndrome**

Myofascial pain syndrome is pain caused by irritation of the fascia and muscle fibres that lasts for an extended period of time. During normal muscle contraction, the muscles contract and then relax as movements are performed. However, sometimes the contracted part of the muscle remains contracted resulting in a trigger point being formed. If there are multiple trigger points in the muscle, it becomes tight and feels like a taut band. Trigger points restrict the blood flow of muscles as they act as a barrier for flow. This causes decreased oxygen to the muscle and an increased build-up of wastes that should be removed by the blood stream. The work of the muscle is therefore not optimal.[47]

- **Joint dysfunction**

Joint dysfunction occurs when a joint does not function as it should and is classified as either hypomobile or hypermobile. Hypomobile joints have restricted motion and therefore do not reach their full range of motion whereas hypermobile joints have an excessive range.

There are a few different reasons for hypomobile joints, the first one is hypertonic muscles that cross the joint. In the lumbar spine, the smaller and deeper intrinsic muscles like the *m. rotatores, m. interspinales* and *m.intertransversii* are the most affected. The formation of bony spurs can also decrease the joint range as well as a build-up of fibrous adhesions causing taut soft tissue. If the fibrous adhesions build up in the ligaments or joint capsules, there is more effect on the joint.

Hypermobility can be a result of overstretching of the joint capsule and ligaments or compensation movements for an adjacent joint that is hypomobile. In the spine, the joints are particularly close to one another so this phenomenon would affect the lower back a lot. [47]

- **Strains and sprains**

Both of these terms refer to the tearing of either a ligament or joint capsule (sprain) or a muscle (strain). The torn tissue will cause inflammation and pain when it is in the acute phase. This situation has a worse prognosis for ligaments than for muscles as ligaments have a limited blood supply which will hinder healing. This type of injury can happen in the lower back during bending when lifting a heavy object or macrotraumas such as falling or a vehicle accident. Strains and sprains can also be a consequence of repetitive microtrauma from overuse injuries like repeated bending.[47]

It is important to note that lower back pain can also be from referred pain. This is pain that is completely unrelated to movement, posture or structures of the spine. For example, pain in the upper lumbar region suggests the possibility of aortic aneurysm, neoplasm or may result from visceral disease.

1.1.7 Diagnosis – clinical and kinesiological assessment of the lumbar spine

A clinical examination should be performed in order to decide what type of treatment is appropriate and if further evaluation or imaging is necessary. Clinical clues, or red flags, may help identify cases of specific low back pain and prompt secondary examinations. In the field of physiotherapy, assessments aim to identify impairments that have contributed to the development of symptoms. The assessment does not focus on anatomical structures like intervertebral discs but rather on biological factors (weakness, stiffness), psychological factors (depression, anxiety, fear of movement and

catastrophising) and social factors (age and occupation). Due to the fact that non-specific back pain has no identifiable anatomic pathology, it is important to consider the exposure of patients to risk factors.[49,50]

1.1.7.1 Patient anamnesis

Before a physical examination of a patient, it is always necessary to start with gathering an anamnesis. This includes their medical history and symptoms. Examination techniques give information about the current state of the patient but since lower back disorders can diversify, history is important because it gives information of the evolution of the condition.

Pain is usually what leads the patient to seek treatment and is the most important symptom. We should determine the characteristics of the pain such as the onset, duration, localization, its influence on life, and if it is combined with other symptoms such as weakness, numbness, paraesthesia or cold foot. The patient's activity level as well as physiological functions like sleep habits, incontinence and bowel movements is also important. As we are working with chronic lower back pain, getting a clear idea of any injuries the patient has suffered from previously and any previous attacks is essential. The rehabilitation and pharmacological history also provide vital information about the evolution of the disorder.

The following table shows the symptoms that can be found with common pathologies. Certain key facts found in the history examination can give us a clear idea of what condition could be present. [51]

Diagnosis	Age	Pain localization	Dural symptoms	Posture	Exertion
Discodural backache	15–70	Lumbar gluteal	+	Sitting provokes Walking eases	Bending provokes
Postural syndrome	30 or younger	Lumbar	–	Provokes	Eases
Lateral recess stenosis	Elderly	Leg, unilateral segmental	–	Standing and walking provoke Sitting, lying or bending forwards eases	No influence
Sciatica	Usually 20–50	Leg, unilateral segmental	+	Sitting often provokes Supine lying often eases	Provokes
Ankylosing spondylitis, 'active stage'	15–35	Lumbar; less often unilateral gluteal	–	Often worst on waking	May aggravate pain already present
Spondylolisthesis	15–35	Lumbar, bilateral sciatica	–	Prolonged standing provokes	Largely unconnected with exertion
Spinal malignant disease	No particular age Increasing central backache in an elderly patient	(Upper) lumbar, legs; multisegmental distribution	+	No particular postures, worse at night	Muscle spasm markedly limits movements

Figure 7: Specific lumbar spine pathologies with their typical clinical signs and histories [51]

1.1.7.2 Lumbar spine physical examination

The goal of a physical exam is to further narrow down possible causes of pain. In order to avoid missing any important information, the examination must be performed in a practical and orderly routine. The essence of an assessment procedure is to further stress the compromised tissue with the intention of reproducing or creating signs or symptoms of the problem. The goal is to determine the degree of disability, so the physiotherapist needs to inspect the patient from the moment they walk into the room. Tests are conducted in a standing position first, followed by supine and prone lying.

The physical examination involves specific components:

- **Postural assessment**

We should analyse the static posture of the patient from an anterior, posterior and lateral position to look for any asymmetry, imbalances or non-physiological positions. The assessment looks at the position of the spine, neck, pelvis, shoulders, shoulder blades, hips, knees, ankles and feet. Bad posture places excessive physical stress on tissues of the body and can cause functional problems in the musculoskeletal system.

- **Range of motion (ROM) assessment**

We test both active and passive range of motion. Active ROM is performed by asking the patient to actively contract the muscles of the lower back, pelvis, and hip joint to move through all cardinal planes. Passive ROM is performed by the therapist moving the patient's body without their assistance. It is important to note any pain and use a goniometer to measure the actual degree of movement.

Specific dynamic range of motion tests for the spine can be performed. These examinations test the spinal extensibility in different spinal sectors. These include: Schober, Stibor, Side-bending, Thomayer and Otta's test.

- **Palpation assessment**

This part of the assessment involves using touch to examine the bony structures and soft tissues of the patient. In the lumbopelvic region, it is important to palpate the iliac crests, anterior superior iliac spines (ASISs), and posterior superior iliac spines (PSISs) to assess if the pelvis is in a physiological position. We also need to palpate the spinous processes of L1-5 as easy palpation of these structures can indicate increased lordosis.

Once we have examined the bony structures, we examine the soft tissue to determine if there is muscle hypertonus - specific trigger points or overall tightness. Palpating for swelling and increased temperature may reveal tissue inflammation; palpating for thickness and increased density within a soft tissue may reveal the build-up of

fibrous adhesions within the tissues. Palpation can also be useful to determine joint abnormalities.[51]

- **Joint play/mobilization assessment**

Joint play assessment, like joint mobilization technique, is performed by bringing the patient's joint to the end of its passive ROM and then gently applying a small, even, steady force for less than a second that further stretches the joint in the desired direction.[51]

- **Special assessment**

Neurologic examinations as well as reflex tests are part of the special assessment so that neurological involvement due to space-occupying lesions like spinal stenosis and disc herniation can be ruled out.

- Straight let raise test is performed in order to stretch the sciatic nerve.
- Active and passive SLR tests can also be used to assess for sacroiliac and lumbar strains and sprains as well as sacroiliitis.
- Piriformis test/Patrick's test is used to assess piriformis tightness and if it could be compressing the sciatic nerve.

It is important for the therapist to be aware of the 'red flags of back pain' when performing an assessment so that more serious pathologies are not overlooked. These are clinical findings that cause an increased suspicion of a more serious pathology such as cancer, infection or a fracture. When physiotherapists identify red flags they should refer the patient for further clinical diagnostic tests which will be discussed in the next chapter. [52]

"Red flags include: recent significant trauma, prolonged glucocorticoid use, age <20 or >55 year, radiculopathy (radiating pain with a dermatomal distribution pattern), bladder or bowel dysfunction, severe or progressive sensory or motor disturbance, history of malignancy, unexplained weight loss, pain worsening at night, fever/chills/fatigue, immune compromise, history of arthritis, morning stiffness or improvement with movement." [53]

1.1.7.3 Imaging tests of the lumbar spine

Diagnostic investigations are particularly important when the physician suspects that the cause of back pain is specific. Imaging tests are performed to confirm the clinician's diagnosis, as treatment for specific conditions would differ to those of non-specific origin. Confirming the diagnosis via imaging allows for safe and appropriate

interventions. Since many cases of back pain are benign, they resolve after conservative treatment and so do not require imaging. Imaging methods are expensive with some risks and radiation exposure so should be avoided if it is not necessary. [54]

A summary of Clinical guidelines issued by NICE (UK, 2016), KCE (Belgium 2017), the Danish Health Authority (2018) and the American College of Physicians (2017) has been developed to give common recommendations for the diagnosis of low back pain, which includes the following:

- "Diagnostic triage (non-specific low back pain, radicular syndrome, serious pathology).
- Screen for serious pathology using red flags.
- Physical examination for neurologic screening (including straight leg raising test).
- Consider psychosocial factors (yellow flags) if there is no improvement.
- Routine imaging not indicated for non-specific low back pain.
- Lumbar examination".[55]

The most important imaging methods used for the lumbar spine are X-Ray, Computer Tomography (CT) and Magnetic Resonance Imaging (MRI). X-rays are considered as a first-line imaging method. A CT is the best to evaluate the integrity, alignment and pathology of the spinal vertebrae, but MRI is the best for evaluating softer tissues such as discs, nerves and ligaments.

1.1.8 Treatment of chronic lower back pain

1.1.8.1 Conservative treatment of chronic lower back pain

Conservative treatment is a non-invasive method for the treatment of pain. It consists of 3 main methods:

- **Pharmacological medicine**

Any medication needs to be prescribed by a physician. The most commonly administered drugs for back pain are:

- NSAIDs (Non-Steroidal Anti-Inflammatory Drugs) such as Advil or aspirin
- Muscle relaxants
- Tramadol
- Corticosteroids

According to NICE guidelines (2016), it is important that a patient is put onto the lowest effective dose for the shortest possible time frame. The guidelines emphasize that the use of NSAID's needs to be carefully considered due to the possible risk of side effects. Potential differences in gastrointestinal, liver and cardio-renal toxicity, and the person's risk factors, including age need to be taken into account.

- **Steroid injections**

Cortisone injections are the most widely used steroid injection. They are administered in order to decrease inflammation and alleviate pain. Their effects can last anywhere from 6 weeks to 6 months after administration.

- **Physical therapy**

This includes exercising to strengthen and stretch specific areas as well as manual therapy and patient education.[56]

Conservative care normally utilizes a variety of different methods and techniques that are combined to provide optimal pain relief for the patient. In the majority of patient cases, conservative care will treat the patient. Further explanation of rehabilitation methods is described in chapter '1.2.1 Complex Rehabilitation'.

1.1.8.2 Invasive treatment of chronic lower back pain

Back surgery is rare but may be considered for severe lower back pain that does not improve after a 6 to 12-week course of nonsurgical treatments. It is almost always the patient's decision to have back surgery, and only in rare situations is immediate surgery performed for low back pain.

There are three main types of back surgery to treat pain:

Spinal decompression – bones, bony spurs or ligaments of the spine are removed to create extra room in the spinal canal and alleviate the pressure that was being placed on spinal nerves.

Spinal fusion - vertebra are fused together to prevent joint motion when back pain is triggered by movement.

Disc replacement (Discectomy) – removal of the damaged part of a disc after herniation occurs. [57]

1.1.9 Prognosis of chronic lower back pain

Acute low back pain is highly prevalent with a presumed favourable prognosis however once it turns to chronic lower back pain, it becomes a disabling expensive condition. Findings suggest that the prognosis is relatively optimistic for patients with chronic lower back pain. Generally, the clinical course of a lower back pain episode appears favourable, but back pain among persons in a primary care setting typically has a recurrent course (characterized by variation and change), rather than an acute, self-limiting course. Chronic lower back pain tends to be a persistent condition that requires ongoing management and treatment. The prognosis of chronic lower back pain can vary depending on many factors. If a patient's diagnosis is recent and is non-

radicular, the prognosis is favourable compared to a patient that has intense levels of pain and previous disability records. [1]

In general, chronic lower back pain can be a challenging condition to treat, and complete relief of symptoms may not always be possible. However, with proper management and treatment, most people with chronic lower back pain can achieve significant improvement in their symptoms and quality of life. The potential for prevention is great if adequate tools for intervention are used.

Socioeconomic factors are clearly implicated in chronic lower back pain. Some of the factors that can affect the prognosis of CLBP include:

- Underlying cause: The underlying cause of the pain can play a significant role in the prognosis. For example, if the pain is caused by a degenerative condition like arthritis or a herniated disc, the prognosis may be less favourable than if it is caused by a muscular strain that can be treated with rest and physical therapy.
- Age and overall health: Older adults and people with underlying health conditions may have a more challenging time recovering from chronic lower back pain.
- Duration and severity of pain: Chronic lower back pain that has been present for a long time or is very severe may be more challenging to manage and may require more intensive treatment.
- Treatment: The type and effectiveness of treatment can also play a significant role in the prognosis. People who receive early and appropriate treatment for their chronic lower back pain are generally more likely to achieve better outcomes than those who do not.
- Possible indicators of poor outcomes can also be: fear/pain avoidance, low mood, job dissatisfaction and ongoing suffering.

1.1.10 Relationship between chronic lower back pain and psychology

There is a well-established relationship between chronic lower back pain and psychology. Chronic pain can have a significant impact on an individual's mental and emotional well-being, and psychological factors can also contribute to the development and maintenance of chronic pain.

Psychological factors that contribute to chronic LBP-related disability and delayed recovery include negative pain beliefs, fear-avoidance behaviours, pain catastrophising, depression, anxiety, stress, job dissatisfaction and poor self-efficacy. These cases of pain and psychological overlay can prevent conservative treatment from being completely effective. Depression can make it more challenging for the patient to deal with their diagnosis and anxiety and stress increases overall tension and decreases the pain threshold. Furthermore, chronic pain can also lead to psychological issues such as depression, anxiety, and social isolation, which can then further exacerbate the pain. This cycle can become self-perpetuating, with pain leading to psychological distress, which then worsens the pain, and so on. Inconsistent or conflicting test results can be a

sign of psychological overlay. It is important to determine the patient's subjective idea of their pain and take note of any yellow flags in the clinical examination. Yellow flags are psychological risk factors that contribute to the development of chronic lower back pain.[58,59]

Yellow flags include:

- "a belief that pain and activity is harmful or severely disabling
- fear-avoidance behaviour
- sickness behaviours
- low mood
- social withdrawal
- the expectation that passive treatment rather than active participation will help
- issues with the compensation system
- poor job satisfaction
- difficulty at work
- overprotective family
- lack of social support
- financial problems
- somaticizing tendency"[53]

Given this bidirectional relationship, it is essential to address both the physical and psychological aspects of chronic lower back pain in treatment. Approaches such as cognitive-behavioural therapy (CBT) can be helpful in addressing negative thinking patterns and teaching coping strategies for managing pain. Mind-body techniques such as relaxation, meditation, and mindfulness can also be helpful in reducing stress and anxiety and promoting relaxation. Addressing the psychological aspects of chronic lower back pain as part of a comprehensive treatment plan can help improve outcomes and overall quality of life for individuals with this condition.

1.1.11 Social impacts of chronic lower back pain

Chronic lower back pain can have a significant impact on an individual's social functioning and overall quality of life. Pain can make it more challenging to participate in social activities or maintain social relationships, leading to feelings of isolation and loneliness. Individuals with chronic lower back pain may also be more likely to have trouble in their personal and professional relationships due to their pain and associated limitations. Performing daily activities, such as household chores and self-care becomes more complex. This can lead to a dependency on others for help, which can impact an individual's sense of independence and self-esteem.

Additionally, chronic pain can contribute to financial stress due to decreased work productivity and increased medical expenses. This can further impact an individual's social functioning by limiting their ability to participate in activities or events that require financial resources. Overall, chronic lower back pain can have a significant negative impact on an individual's social functioning and overall quality of life, making it important to address both the physical and psychosocial aspects of the condition in treatment.[60,61]

1.1.12 Prevention of chronic lower back pain

In the case of chronic back pain, secondary and tertiary prevention would be most valid since the diagnosis has already been made by the physician. Secondary prevention is defined as "the prevention of recurrences or exacerbations of a disease that already has been diagnosed. This also includes the prevention of complications or after-effects of a drug or surgical procedure". Tertiary prevention is defined as "measures aimed at providing appropriate supportive and rehabilitative services to minimize morbidity and maximize the quality of life after a long-term disease or injury is present".[55]

Physical exercise is recommended to prevent consequences of low back pain, such as an absence of work and the occurrence of further episodes. Physical exercise is especially useful in training back extensors and trunk flexors in conjunction with regular aerobic training. A high-intensity back school program is advised in patients with recurrent and lasting low back pain but not in preventing low back pain. Lumbar supports, back belts and shoe insoles are not recommended in the prevention of low back pain. Lumbar supports and back belts have also been shown to have a negative effect on back pain beliefs and are therefore not recommended in preventing low back pain. Specific mattresses and chairs for prevention have no evidence in favour or against. Medium support mattresses may decrease existing persistent symptoms of low back pain. Ergonomic adjustments regarding the work environment can be necessary and useful to achieve earlier return to work. [55]

1.2 SPECIAL PART

1.2.1 Complex rehabilitation

The focus of this part of the thesis will be on conservative treatment in the form of physical therapy, for chronic lower back pain with and without sciatica that is treated ongoingly. It will focus on pain aetiology being degeneration processes of both the vertebra and discs, more specifically – spondylarthritis, spondylosis, retrolisthesis and disc protrusion. It is important to note that patients with chronic lower back pain can

experience acute exacerbation periods where rehabilitation is needed to relieve their pain so that they can return to their daily activities.

According to Kolar, a requirement of successful therapy is that the patient should not be a passive receiver of therapy but rather actively co-operate in the rehabilitation process. Studies have shown that an active approach to chronic LBP to focus on functional recovery is more effective than passive approaches that emphasize pain relief. The beginning of rehabilitation of a relapse phase should therefore entail both passive and active methods. Medication, soft tissue work, thermotherapy and electrotherapy can assist with pain relief, but it is important to slowly integrate activity that is bearable for the patient and is without pain or discomfort. Reducing pain and improving function for patients with low back pain involves two components: removing the stressors that create or exacerbate damage and enhancing activities that build healthy supportive tissues. [8]

Medical rehabilitation needs to consider the mental, physical, social and occupational factors of the patient and so multidisciplinary rehabilitation programmes are widely used for patients with chronic low back pain. Many models of therapy have been postulated and applied to treat these patients. Literature shows three frequently used models regarding the development and maintenance of the functional limitations present with CLBP. The first model is the physical deconditioning model. This assumes that the loss of muscle strength, endurance and aerobic capacity is responsible for reduced activity levels and hence the functional limitations. The cognitive-behavioural model is the second theory which links functional limitations to maladaptive beliefs and avoidance behaviours that are maintained by learning processes. The biopsychosocial model combines these two theories and postulates that the loss of functional abilities results from both the deconditioning and the cognitive-behavioural model.

All patients are different and so individualized therapy is appropriate which can present as a difficult task when treating these patients. The rehabilitation plan needs to have clear goals so that a structured programme can be followed and the best outcome can be achieved.[62]

1.2.1.1 Initial short-term plan of rehabilitation

This plan refers to the short-term treatment of a relapse of pain symptoms for a patient suffering from a chronic and long-term pathological situation of the back.

A transition from passive to active forms of care is clinically necessary to enhance functional recovery in the LBP patient. Passive therapy in the form of soft tissue work and therapeutic modalities can be used in the early stages when the pain is severe, but this inactive phase should not last for a long period of time. It is essential to keep the patient active as physical inactivity causes adaptive reductive remodelling of muscles. This process is a composition change of the muscles and causes muscular atrophy and a reduced muscular strength. Atrophy is combined with an increased fat content and

means that more pressure is placed on nerves during movement allowing for pain progression. Immobility also causes quicker dehydration and degeneration of discs.[55]

The treatment plan constructed by the physiotherapist after the clinical and kinesiologic assessment (described in the above chapters of this thesis) needs to incorporate a variety of approaches so that therapy can be effective in increasing the tolerance and capacity of the trunk to control movement and sustain loads placed on it.[55]

Rehabilitation of chronic LBP is an on-going process even after the patient has completed their inpatient treatment with the physiotherapist. They are responsible for keeping their back strong and managing their condition. The patient will experience setbacks along the course of their chronic condition, so it is essential to focus on perfecting certain base exercises and re-establish slow improvement during the short-term phase of rehabilitation and then increase the intensity of the program once again.

The main goals in rehabilitation are:

- Manage Pain.
- Manipulate/mobilize stiff joints.
- Relax and lengthen tight myofascial structures.
- Train motor control of spine, pelvis, and lower extremity.
- Train the strength of large prime mover muscles.
- Educate the patient about correct posture and ergonomics.

1.2.1.2 Long-term plan of rehabilitation

The long-term plan of rehabilitation involves the maintenance and improvement of the short-term plan and is an ongoing process. The goal is to find treatments that allow the patient to manage their pain and symptoms and keep an active lifestyle. The patient's strength needs to be built in all aspects of the body as well as loosen the tight muscles and joints to allow a greater range of motion. The patient is advised to continue with the exercise units that are followed during the short-term rehabilitation. Keeping an active lifestyle in the correct manner is important here. Pilates exercises can be a good way for patients to strengthen muscles involved in the lumbar spine stabilisation as it involves an isometric contraction of abdominal muscles, pelvic floor muscles, gluteus maximus and multifidus muscles. Due to the limited time in short-term therapy, it is difficult to solve the problem of shortened muscles as well as the weak muscles so this will be an important aspect of the long-term plan.

1.2.2 Rehabilitation methods

“Supervised exercise therapy associated with an educational component has been considered one of the most effective interventions in reducing pain and disability in patients with chronic nonspecific low back pain. The effects of exercise therapy tend to remain for at least 6 months after treatment compared with usual care. Furthermore,

there is evidence that exercises also may reduce the number of recurrent episodes of low back pain. "[63]

1.2.2.1 Kinesiotherapy

Aerobic exercises

Aerobic exercises elevate the heart rate and improve circulation throughout the body which results in decreased stiffness and a larger amount of nutrients reaching the spine. It utilizes the aerobic energy-generating process and provides cardiovascular conditioning. In chronic LBP, we need to take care of the spine and jarring movements are contraindicated, so low-impact aerobic exercise is beneficial for those with back pain. One of the benefits of aerobic exercise is that the spine is kept mobile which can reduce the likelihood of severe flareups. Endorphins are a source of natural painkillers and aerobic exercise causes a release of these therefore another benefit is pain reduction. Aerobic exercise helps to keep a healthy body weight and decreases the risk of comorbidities therefore keeping flexibility and decreasing the pressure placed on the spine. During a pain flareup, the rehabilitation program should include around 5-10 minutes of aerobic activity. As the patient's symptoms improve, they should spend around 20-30 minutes a day doing either walking, stationary cycling, using the step machine or water aerobics. [64]

Spinal stabilization training

A lumbar stabilisation exercise programme is designed specifically for each patient relating to their condition. Active protection of the lumbar spine is important to prevent strain of the back during exercise.

Spinal stabilization training puts emphasis on reconditioning key spinal stabilizers by producing quality movements. The goal is to improve the control and coordination of the abdominal and lumbar trunk muscles and increase their endurance and strength. The strength alone of the deep stabilization system muscles does not determine the core stability, but precise coordination of these muscles to generate intra-abdominal pressure is essential too. This training method is very advantageous for chronic lower back pain patients as the target muscles are affected without aggravating the symptoms. Functional deficits need to be noted in the kinesiological examination and these determine the positions of stabilization exercises that the physiotherapist will incorporate into training. Lumbopelvic control via abdominal co-contraction and pelvic tilting forms the basis of these exercises. Another benefit is that it can be used with patients in the late acute phase of symptoms even with radicular syndromes and is effective for self-therapy.

There are different stages of spinal stabilization which correlate to the three main features of spinal stabilization programmes.

Stage 1 consists of facilitating the oblique abdominals, transversus abdominis, and multifidus. This stage is important as co-contraction can enhance stability and this needs to be accomplished before any load is placed on the spine. Co-activating the abdominal muscles with the deep spinal extensors helps to achieve lumbopelvic awareness and stability. Abdominal hollowing (AH) is used to separate the activity of rectus abdominis from the oblique abdominals and the transversus abdominus. AH is performed by pulling the abdomen in toward the spine without allowing significant lumbar flexion. This causes elevation of the ribs. Hollowing can be done in sitting, standing, prone lying and four-point kneeling. Abdominal bracing is another technique that can be used which is accomplished by increasing the intra-abdominal pressure while co-contracting. Bracing is the isometric contraction of the abdominal wall.

The second stage involves tilting of the pelvis to gain lumbopelvic control. This is done in different positions depending on what is comfortable for the patient. There are six basic positions. Patients are taught to exercise in their safety zone which is their pain-free range of motion.

Lastly, the three techniques mentioned above are used to perform functional exercises. [65]

McKenzie Therapy

The philosophy of this method, developed by Robin McKenzie, is to influence primary, secondary and tertiary prevention in patients with spinal problems. Treatment is selected based on the patient's diagnosis classification and is based on pain reaction. McKenzie therapy includes assessment and then active participation of the patient in therapy. It is a biopsychosocial system of musculoskeletal care emphasizing patient empowerment and self-treatment. The patient can be placed into one of 3 possible categories once subjective symptoms have been established. The first one is postural syndrome, the second one is dysfunction and the third is derangement syndrome. Postural syndrome is caused by certain positions that are maintained for a prolonged time. Lumbar dysfunction is caused by scarring of the tissue and derangement syndrome is a result of lumbar disc movement occurring. The assessment uses repeated movements as well as the centralisation phenomenon to diagnose the patient. The term centralization refers to the approximation of symptoms towards the spine. It has reference to the prognosis of the treatment – if there is a decrease in the pain and a shift of symptoms to the midline from the periphery then the repeated movements is a good sign of prognosis. However, if there is peripheralization then the pain increases and shifts to the lower extremity and the examination should continue, to allow the therapist to adjust the treatment. There are 18 principles of treatment that the therapist can select from and then work with the centralization phenomenon to guide the patient.

Brunkow method

Brunkow method is a set of exercises that results in the activation of the deep stabilization system and is based on the principle that motor activity depends on the position of the extremities in relation to the trunk. Brunkow method activates diagonal muscle chains and achieves an upright position of the trunk using the support of an extremity. It attempts to distinguish incorrect pathways of physiological patterns. The method utilizes exercises that involve leaning on the arms and legs which are set in the correct and physiological position. Through this creation of tension, various coordination and muscle chains are activated. [27,66,67]

The exercises start with dynamic contraction of the hands and feet with a fixed point on the wrist and/or heel. This then transfers through the kinetic chain and leads to isometric contraction of the group of muscles, which must be included in the exercise. Starting positions determine the group of muscles to be trained and respect the developmental stages of a child's motor system and uses only partial elements of posture. This exercise method helps to activate and coordinate muscle chains that may be weakened or overworked. [27,66,67]

Strengthening

Strengthening exercises help to create balance between muscle groups and build muscle mass. The strength of muscles can be improved by increased resistance in the direction of the specific muscle's contraction from its origin to insertion. Due to the central nervous system responding to individual movements rather than specific muscle activation, strengthening techniques focus on the muscle's corresponding movement rather than the muscle itself. Core stabilization strengthening should be directed toward the anterior abdominal wall musculature as well as the low back extensor muscles. Abdominal muscles help to maintain the correct curvature of the spine and a neutral pelvic position so when these muscles are weak it can leave the body more prone to poor posture and put more stress on the other supporting structures of the spine. Strong muscles in the back are important for spinal stability to keep the vertebrae properly aligned. Strengthening these two groups of muscles is essential for preventing and reducing back pain. Strengthening of the gluteal and pelvic floor muscles also plays an important role due to their connection with the spinal structures.

Stretching

Stretching is a vital component of rehabilitation and daily life as flexible muscles are less prone to injury. Tight muscles restrict circulation thereby reducing the amount of oxygen and nutrients that reach the muscles. When there is prolonged tension in muscles, it turns into tightness and causes pain. Flexibility allows muscles to assume the

neutral position more easily. Stretching increases the blood flow to joints and muscles resulting in a widened range of pain free motion. An overall release of tightness and stress in the body is achieved when stretching. Stress prompts the release of the 'fight-or-flight' hormones, adrenaline or cortisone, but stretching has been shown to increase serotonin levels leading to reduced stress. Stretching can be done passively by the physiotherapist or actively by the patient. [68]

Proprioceptive Neuromuscular Facilitation

This is a type of pre-contraction stretching that involves the contraction and stretching of a muscle. It can be used to increase muscle tone while relaxing muscles. This method utilizes the mechanism of proprioceptive facilitation to quicken responses of the neuromuscular system. It involves the muscle being held in a stretched position by the physiotherapist followed by the patient contracting the muscle and then the physiotherapist further stretching the muscle. This is what we call the contract-relax method and pushes the muscle to its limit triggering the inverse stretch reflex. [68]

Posture corrections

Physiologic posture is defined as the position of the body that has minimal energy consumption and maximum stability. Abnormal posture is when the spine is positioned in unnatural positions and this creates abnormal stress and strain in many spinal structures. Postural abnormalities are considered predisposing factors for chronic lower back pain.[69]

Muscle imbalances occurring in the pelvic region results in Lower Crossed Syndrome. It is characterized by hyperactivity of the hip flexors and spinal extensors but weakness of the abdominal and gluteal muscles. This pushes the pelvis into an anterior pelvic tilt which consequently leads to hyperlordosis. Increased lordosis places strain on the lumbosacral region and the biomechanics of the hip and spinal joints are affected by Lower Crossed Syndrome. Posture correcting involves strengthening of the weakened muscles and stretching the tight muscles to achieve an optimal stance even with applied pressure to the body. Patients should be educated about the importance of symmetrical weight distribution across the soles of the feet and keeping an elongated position of the spine. [27]

Sensorimotor stimulation (SMS)

Sensorimotor activities are tasks and exercises that engage and strengthen the brain by activating our body and our senses at the same time. It is also known as proprioceptive postural training. Proprioception is the sense of the body's position in space. The skin, muscles and joints have specific mechanoreceptors and proprioceptors which

allow for identification of limb position via neural signalling when there is a change in the skin, muscle, or joint stretch.

Correct support of the body is a prerequisite for straight body alignment and correct breathing, so it is important to focus on the correct centration of specific points in different positions. The foot forms the basic support for the upright posture through signals that are sent to the CNS. The foot arch, support points as well as pre-stretch of the muscles all influence the signals. If the foot is not stabilized properly then the diaphragm and thorax adapt to this position and their function is consequently adapted too. Stabilization training of the foot on different surfaces and combining it with balance exercises is an essential part of therapy. Through this training, we unconsciously involve muscles that are usually difficult to affect consciously, helping to automize muscle activity and positively influence muscle tension and re-learning of optimal execution of movement patterns occurs. We use the concept of "small foot" which involves teaching the patient about symmetrical load distribution in the foot. The weight should be distributed between the first metatarsal, the 5th metatarsal and the tuberosity of the calcaneus. It is important to stimulate the foot receptors and muscles with a textured ball or alternating between hot and cold towels before training to enhance the effects. During training the patient can stand on a balance board, a foam balance pad or a spiked balance disc and in the beginning stages focuses on forming the small foot. As the training progresses the patient can be asked to perform anterior-posterior weight shifting as well as lateral weight shifting while keeping balance, balance on one foot or involve some upper extremity movements.[70]

Gait re-education

Gait retraining aims to correct abnormal mechanisms of walking and is a movement specific intervention. Normal gait requires synergy of muscles and joints so if certain muscles or joints work more effectively than others, the gait will be unfavourable. This involves teaching the patients about the correct movement stereotype of gait and improving the gait cycle. Learning the correct biomechanics of the pelvis, knee and foot is the focus of this training, but it also emphasizes the importance of the arm swing. The arm swing assists with balance and helps with weight shifting, if this is limited it can result in overuse of the hip flexors and extension of the back. The movement should come from the shoulders and not the elbows.[71]

1.2.2.2 Manual Techniques

Manual techniques involve the therapist using their hands to provide skilful movements of the soft tissue and joints. Soft tissue dysfunction can affect the rehabilitation process so it is important to restore their normal function so that the patient's

condition can be improved. A combination of techniques can be used as dysfunction in one structure can also cause dysfunction in another type of tissue.

Soft tissue techniques involve influencing the skin, subcutis, fascia and muscles. When working with the soft tissue we should start from the most superficial tissue and work our way into the deeper tissue as superficial adhesions can disrupt deeper layers. Hyperalgic skin zones which have a greater resistance are treated first by reaching the barrier and waiting for release. We then move on to the fascia, specifically the thoracolumbar as well as the lateral and gluteal fascia. Proper mobility and fascia elasticity are essential for free physiological movement and mobility disorders in the fascia tend to be characteristic in the chronic stages of illness. We use respiratory synkinesis in the form of inhale-exhale for the treatment of fascia. Soft tissue mobilization uses deep pressure and stretching to break up rigid muscles to relax any tension and shift fluids from inflammation away from the muscles.[72]

Post Isometric Relaxation is used to treat muscles through stretching. This technique utilizes energy directly from the muscle in the form of gentle isometric contractions resulting in relaxation and lengthening of the muscle via reciprocal inhibition. Myofascial Pain Syndrome and trigger points in muscles are treated with PIR. PIR is commonly used on patients with low back pain to lengthen short hamstring muscles that can contribute to their low back pain. Ischemic compression can also be used to treat trigger points.

PIR has 3 phases:

1. Pretension – stretching in the direction of the muscle fibres without force.
2. Isometric phase – uses looking, inhalation, exhalation, gravity and minimal resistance.
3. Relaxation phase – uses gravity, looking, inhalation, exhalation, relaxation and waiting for release. We should be careful not to initiate the stetch reflex.[73]

Mobilisation, Manipulation and Traction techniques utilize force in order to separate bones at the joint and additionally to lengthen soft tissue in the area. Increased tension in some muscles could be due to joint blockages. Mobilizations are contraindicated when degenerative changes are present in the spine as increasing the pressure on the discs can increase the size of the bulge or rupture. The primary focus when treating these patients should be to loosen muscles and fascia surrounding the disc so that they do not put more pressure on the disc. Lumbar spine traction or distraction should be performed carefully when there is disc pathology but can be beneficial for relieving disc pressure. All movements of the client's lumbar spine should be done with caution.

1.2.2.3 Physical modalities

Physical modalities can be incorporated to facilitate a quicker recovery. Some of the main benefits of modalities include reducing inflammation, decreasing muscle spasms, promoting tissue healing and decreasing pain. There are many different types of modalities that can be used and are effective, but I will focus on thermotherapy and electrotherapy.

Thermotherapy comprises the use of any superficial heat application to the skin. One of the forms of thermal therapy is the use of a hot pack (Vulcanpack) which has many benefits that can assist with reducing pain and disability and increasing healing in the tissues. It is applied in practice and is also an inherent part of patients' self-administered treatment. Increased tension in the back area can increase symptoms of pain. Heat packs improve symptoms by dilating the blood vessels in the lumbar spine muscles. This results in an influx of oxygen and nutrients and so promoting healing and stiffness reduction as it facilitates stretching of the soft tissues. This modality also works by interrupting the transmission of pain signals due to the gate-control theory. It affects the receptors in the skin and activates heat-sensitive calcium channels that can block pain receptors directly or stimulate other sensory receptors to reduce pain indirectly. A decrease in pain sensation and stiffness in the tissues also makes exercises more tolerable.

Heat should however be avoided in the first 48 hours of an acute episode as the short-term effect of heat application on damaged, infected, or swollen tissues is an increase in inflammation. [74]

Electrotherapy is the use of electric currents or electromagnetic fields passed through the body to stimulate nerves and muscles. Non-invasive electrotherapy is commonly used for the treatment of chronic LBP. The main benefits of this modality include analgesic, myorelaxation, trophic and anti-oedematous effects.

Electrotherapy can be divided into contact or distant electrotherapy. In contact electrotherapy the applicator forms an electric circuit with the treatment segment and includes galvanotherapy, low-frequency and mid-frequency therapy. The effect of contact electrotherapy is based on the electrochemical reactivity of tissues to the current and the stimulation of the neuromuscular system. High-frequency therapy and magnetotherapy fall under distant electrotherapy during which the treatment segment is exposed to the applicators electromagnetic field. Different types of electrotherapies exist based on the type of current used as well as the electrodes, the three basic groups are: galvanic currents, alternating current and pulse direct current.

Dipole vector field is a type of interferential therapy that uses two mid-frequency fields to have the effect of low-frequency electrotherapy without its associated discomfort on the skin. "The transcutaneous application of alternating medium-frequency

electrical currents are applied to the body in such a manner to produce amplitude modulated low frequency current within in the body for therapeutic purposes. It is the production of low-frequency current in the body tissue by the simultaneous application of two different medium frequency currents." It is indicated for chronic and subacute functional musculoskeletal disorders, so it is effective in the treatment of chronic back pain. [27,75]

1.2.3 Occupational therapy

Occupation therapists work to increase a patient's ability to complete activities of daily living that could be hindered by their disorder.

1.2.3.1 Back school

Back school is an educational and training program that serves the purpose of teaching patients about back care and exercises. It is aimed at preventing long-term back problems and is generally a group-based therapy. It is used as a form of secondary prevention for patients that already suffer from either functional or structural problems and are undergoing therapy such as spinal stenosis, disc herniation and spondylolisthesis.

The Swedish Back School was developed by Zachrisson Forsell and consists of four 45-min, mainly audio-visual, lessons under the supervision of a physiotherapist. The goal is for the patient to be able to manage a current episode and prevent relapses. The lessons teach the patients about anatomy and the functions of the back. Patients are taught which postures and positions are most beneficial for the back and which exercises are useful for strengthening the abdominal, gluteal and back muscles. They are also taught about the autodiagnostics of shortened and weakened muscles as well as upper and lower crossed syndromes. Patients are advised to use a wedge for sitting as well as a lumbar lap to ensure optimal biomechanics of the spine in this position. The purpose of back school is not only to create confidence in the patient to cope with their back troubles but also to avoid excess therapy and to decrease the expenses both for the patient and for the society. This training is also a way to place responsibility of the disability on the patients hands so that they have a better management of their condition. [76]

Essential back school tips for patients:

- When lifting objects, bend the knees like doing a squat and lift with the legs as these muscles are stronger and more voluminous than back muscles.
- Avoid standing with all weight on one leg.
- Move objects by pushing or pulling.
- Avoid sports that involve excessive jumping and requires twisting.
- Use the correct sitting posture and place a rolled towel in the hollow of the back to support the lumbar spine.

1.2.3.2 Orthotics

Lumbar back braces are specifically designed to stabilize and support the lower back. A back brace can reduce spinal pressure and unload some of the weight placed on the lumbar spine. It helps to promote proper posture and immobilizes the spine therefore protecting the back from further injuries and decreasing pain. These braces can be used as assistive devices for everyday life for chronic lower back pain patients or they can be prescribed to patients after an injury or surgery as the period of immobilization allows for healing. Braces should be individualized for each patient according to their weight, height and waist girth. [77]

2 Casuistics

I was first introduced to my patient at St Anne's Faculty Hospital in the Inpatient Rehabilitation Department on the 10th of October 2022. Mr. P.M. was in a conscious state and fully cooperative. I introduced myself and along with my mentor, Mgr. Veronika Mrkvicová, explained to the patient that I have been assigned to assist with his rehabilitation in order to complete my bachelor thesis. He gave me informed consent to continue and to use his medical information as well as pictures for the writing of my thesis. Veronika supervised my physiotherapy work with the patient.

2.1 Basic data

Primary diagnosis: LumboIschiadic Syndrome (low back pain with irritation to the lateral side of the thigh of the right lower limb).

- Name: Mr. P.M.
- Age: 78 years
- Sex: Male
- Weight: 90kg
- Height: 174cm
- BMI: 29.7 kg/m^2
- Somatotype: Mesomorph

2.2 Diagnosis at admission to the Inpatient Rehabilitation Department at St Anne's Faculty Hospital (According to Medical Records)

Mr. P.M. was admitted to the Inpatient Rehabilitation Department for exacerbation of chronic low back pain with spreading into right lower limb. His diagnosis is LumboIschiadic Syndrome (low back pain with irritation to the lower limb on the right side).

A CT scan of the lumbar spine was completed on 15.8.2022 and showed numerous degenerative impairments in L1-L5 with slight lumbar flattening. In the sagittal plane, no pathology was seen. On L2/3 there was small ventro-listhesis of 2mm.

His spinal canal measured a width of 11mm in the sagittal plane and the vertebral bodies showed a normal height. The CT showed spondylarthritis and spondylosis in the lumbar region of the spine.

At the level L1/2 and L2/3, no reduction of intervertebral space can be seen. There is disc protrusion of 2-3mm, however the nerve roots are free without compression. At L3/4 there was also no reduction of intervertebral space, and the disc protrusion is 2mm, the nerve roots are free without compression. At L4/5 and L5/S1, we could see degeneration of disc L4/5 and disc protrusion of 3mm. There was no reduction of intervertebral space, but the nerve roots at L4 bilaterally and the left L5 were with compression. The right L5 nerve root is free without compression.

2.3 Description of examination

2.3.1 Case medical history

Anamnesis was taken on 10.10.2022.

Medical history

- Mr. P.M. has suffered from hypertension for multiple years, which he takes medication for.
- He had a benign prostate hyperplasia.
- He has had previous surgeries: he had an Achilles tendon rupture on his right lower limb in 2018 and so received a surgery to suture it. He also underwent surgeries for an inguinal herniation on the right side, nasal septum, and a left leg femoral fracture.
- Fracture of left femoral bone: about 25 years ago over Christmas time (the patient could not remember exactly when it happened). He said that there was a lot of swelling. The fracture was treated conservatively, first they applied traction to the leg and then kept his leg in a splint to immobilize it. He spent one month lying in the hospital (at the Private Clinic in Surgal Brno) and one month lying at home, then he used crutches. Muscle atrophy occurred and he did rehabilitation.

Family history

- Mother suffered from rheumatoid arthritis.
- Father was healthy.
- Both parents were octogenarians when they died
- The patient did not have any siblings.

Social history

- He lives with his wife, in a flat on the 7th floor. There is an elevator in the building. He is currently living off of his retirement pension. The patient was an engineer, in foundry. His work was not physical in terms of lifting, carrying, or manual work but rather required walking, drawing, counting, thinking, and standing. For 44 years he did the same job, in the same place and he was very happy.

Physiological function

- No pathological physiology. The patient sleeps well and has a good appetite. Stool and urination is regular with a tendency to flatulency.
- He sleeps while lying on his side as he snores.

Allergies, blood transfusion, abuses

- None

Pharmacological history (from medical records):

- *In the hospital:* pain killers (Almiral 75mg i.v. daily, if necessary and the pain is more than 3/10 on the visual analogue scale (VAS), Paramax rapid 500mg, antihypertensives (Vidonorm 4mg/5mg 1-0-0), Nolpaza 40mg 1-0-0, Zolpidem 10mg 0-0-1 (if problems with sleeping).
- *Regular remedies at home:* Vidonorm 4mg/5mg, Nolpaza 40mg.

Sport history

- Volleyball: at 20 years of age, for 2 years he played actively in a league and after this he played occasionally in a recreational manner. He has played his whole life but as his back worsens, he plays the sport more lightly with less jumping and softer hitting of the ball. At a younger age he jumped a lot which could have caused microtraumas.
- Gymnastics: at a younger age. He could touch the floor with his palms. This could show that he had hypermobility which now affects the spine.
- He now does walking, cycling and plays football in a calm manner: irregularly and recreationally.

Rehabilitation history

- In summer 2019 he received outpatient rehabilitation care for low back pain. Here he received kinesiotherapy, electrotherapy and manual techniques. In 2018 he also received outpatient rehabilitation after his Achilles tendon suture.

2.3.2 Present State

Subjective examination:

Pain according to the visual analogue scale (VAS)

At rest pain is a 3/10. During exercise or movement the pain is 7/10.

Present complaints

He suffers from pain in lumbar area that has lasted for many years but has progressively worsened in the last month. The pain spreads into his right buttock and down the lateral side of his right leg.

Back:

The problem first started 16 years ago. He was driving for 2 hours to Slovakia to visit a thermal spa. In this driving position, he started to feel that something was wrong but the pain and discomfort was lower down in the sacral area. Over time it started to spread to the lumbar area and he then started rehabilitation as his daily mobility became limited and painful. The patient experiences times of remission where his back is in a better condition but there are other times when it is worse. Recently, in the past 3 or 4 years, he visits the Outpatient Department at St Anne's Faculty Hospital more regularly. He received electrotherapy and isoplanar vector currents over the years.

- *Activities that improve the pain:*

At his computer he has equipment that provides a better sitting position – he has support for behind his back and an orthopaedic cushion below the pelvis.
His symptoms improve when he exercises in the correct positions. Stretching and strengthening the muscles around the spine helps him.

- *Activities that exacerbate the pain:*

Carrying heavy objects and working in a flexed/extended position make his pain worse. Bigger movements in flexion or extension are not optimal. Sitting for a long period worsens the pain, however walking is without problem. Strong exercises in extension or lateral flexion as well as weight lifting cause pain.

Torso:

Once a month for about 15 minutes he has a tension feeling under the ribs that feels like a compression. He does not find it painful but rather explained it as uncomfortable. He waits for a while and breathes deeply and then it disappears. From

what he explained I thought that it could be thoracolumbar fascia, quadratus lumborum, ribs or vertebral joints.

Upper extremity:

He experiences right shoulder joint pain that started 2-3 years ago. He also has permanent pain in the area of acromioclavicular joint and long biceps tendon.
In the right elbow he feels a blockage of the joint. There is less extension on this side as the arm is in continuous flexion. His self-care is limited because he cannot flex the elbow properly and he has pain in his shoulder with internal rotation so he struggles to reach his ear/face.

2.4 Engagement of the author in the process of medical rehabilitation

2.4.1 Initial kinesiological examination

Completed on the first and second day (10.10.2022-11.10.2022) of rehabilitation.

General Observation

Cognitive status: the patient was fully conscious and engaged in conversation.
Lumbar spine: flattened, movements limited and expansion of the spine restricted – both flexion and extension, lateroflexion with limitation to the right, paravertebral spasm at the right lumbar area.
Lower limbs: without problems with sensitivity, without severe weaknesses, active movability without any restrictions.
Gait: stiff, walking on the toes and heels possible, no need of compensatory aids.

Objective Observation:

Postural examination

The patient was observed undressed, with his socks and shoes removed. He was instructed to stand in a comfortable and relaxed position. I examined him from caudal to cranial direction in an anterior, posterior and lateral view.

I first checked his frontal and sagittal statics:

Tested using the 2 scale test:

The patient had a difference of 6kg between the scale with more weight on the left side. This determines a deviation between the frontal statics.

Tested using the plumb line test:

The plumb line was placed behind the patient and divided his body into 2 halves (left and right) to test the frontal statics. I then examined the landmarks that the line intersected, from the cranial to caudal direction. The results were as follows: his head was centrated over his body, his left shoulder sits higher than his right, the spinous processes and the intergluteal cleft are in the centre, there is an elevation of the posterior superior iliac crest on the right side and the space between the malleoli is even.

To test the sagittal centre of gravity the plumb line is placed on the lateral sides of the body and should pass through the mastoid process, second sacral vertebra, hip joint and infront of the ankle and knee joint. The patient's line of gravity in the sagittal plane showed a forward head posture and decreased lordosis which then altered the position of the lower extremity joints.

Anterior view

The patient has a poor standing position – the whole body is tilted to the left

- *Feet:* hallux valgus in both feet. Slight eversion of the feet as well as flat feet.
- *Shins:* the contour of *m. tibialis anterior* was slightly more defined on the right side.
- *Knees*: in a neutral position, with a very slightly increased Q angle of about 16 degrees. Good position and shape of the patellae.
- *Thighs*: slightly more prominent *m. vastus medialis* on both sides.
- *Pelvis*: the anterior superior iliac spine (ASIS) on the right side is lower than on the left side.
- *Abdominal area*: the umbilicus is shifted to the right side, but otherwise there is a relatively good abdominal wall position.
- *Chest and rib cage*: neutral position of the sternum. His jugular notch is quite prominent. Rib cage is normal with no protrusion or widening on either side. Hyperactivity of the left pectoralis muscles.
- *Neck*: hyperactivity of *m. sternocleidomastoid* on both sides.
- *Head*: neutral alignment of the cranium on the cervical spine.
- *Shoulders and upper extremity*: right shoulder is elevated compared to the left side. There is hypertrophy of *m. trapezius (upper part)* on the right side.

Side view

- *Ankle joints*: plantar flexed position of the right side, the left side is neutral.
- *Knees*: right knee more flexed than the left.
- *Hip joint*: slight hip flexion on the left side.
- *Pelvis*: slight pelvic torsion as there is retroversion on the left side, and a normal position on the right side.
- *Lumbar spine*: decreased lordosis causing lumbar flattening.
- *Thoracic spine*: slight kyphosis with upper and middle thoracic prominence, especially at Th4 and Th8.
- *Cervical spine*: cervical kyphosis.
- *Head*: forward head position
- *Shoulder joints*: protraction of the shoulders on both sides, slightly more on the right side.
- *Elbows joints*: the right elbow is in a resting flexed position, more than on the left side.

Posterior view

- *Feet:* valgosity in both ankles.
- *Calves:* hyperactive *m. gastrocnemius* on both sides.
- *Knee*: the popliteal fossa's are increased because the knees are in constant flexion.
- *Thigh*: hypertrophic hamstring muscles.
- *Pelvis*: groove above the iliac crest is larger on the left side. Higher posterior superior iliac spine (PSIS) on the right side.
- *Sequencing through the spine*: spinal erector muscles are hypertrophic on the right side in the lumbar region. There is also hypertrophy of the paravertebral muscles. No scoliosis can be seen.
- *Scapulae:* hypertrophy of the right rhomboid muscles. Right scapula alata due to winging of the inferior angle.
- *Shoulders*: asymmetry of shoulder and shoulder blade level (right one is higher).
- *Elbow*: asymmetry of thoracolumbar triangles (bigger on the left side).

Pelvic examination

Iliac Crests: Same level

Anterior superior iliac spines (ASIS): Lower on the right side

Posterior superior iliac spines (PSIS): Elevated on the right side

ASIS and PSIS (right side): Same level

ASIS and PSIS (left side): PSIS is lower than the ASIS

Result: Patient has slight pelvic torsion

Tests of stability

- *Trendelenburg test:* positive on both left and right side. There was a loss of balance, shaking occurred and the pelvis dropped to each side respectively. The trunk shifted backwards to compensate for the pelvic drop.

- *Rhomberg standing positions:* no pathology – all negative (eyes closed with wide stance, eyes open with narrow stance and closed eyes with narrow stance).

- *Movement from heels to toes:* possible without a loss of balance.

Spine dynamic tests

Flexion of the spine in standing

- Decreased ROM as this movement causes pain in the lumbar region
- Pelvis tilts anteriorly
- No scoliosis
- Thoracic kyphosis with overactive paravertebral muscles and a prominent hypertrophy of the rhomboid muscles
- Flexion at the lumbar area was with minimal expansion compared to the thoracic region

Extension

- The movement was possible but with a decreased ROM as it causes pain in the lumbar area that radiates down the right thigh
- Thoracic overloading

Lateral Flexion

- Minimal movement here especially to the right side
- Thoracic overloading

- Rotational synkinesis of the pelvis is present

Rotation

- Tight thoracic region resulting in a limited ROM
- Rotation to the right caused pain in the lumbar area so there was decreased ROM compared to the left

Table 3: Spine Dynamic Tests at Initial Examination

Test	Initial Examination	Physiologic Values
Thomayer	+ 50cm	Fingertips should touch the floor
Schober	+ 1.5cm	Increase by 4-5cm during forward bending
Stibor	+ 7cm	Increase by 10cm during forward bending
Anteflexion and retroflexion of lumbar region	Limited	Full ROM
Lateroflexion to the left	13cm	Symmetrical on both sides
Lateroflexion to the right	9cm	
Thoracic rotation to the left	20 degrees	30-35 degrees
Thoracic rotation to the right	10 degrees	
Otto Index Inclination	+2cm	Increase by 3.5cm during forward bending
Otto Index Reclination	-1.5cm	Decrease by 2.5cm during backward bending

Gait Examination

- Stiff gait with limited upper limb movement and a narrow base
- Minimal pelvic and trunk movements
- Strides have an equal length
- Protrusion of the head
- Limited hip extension

Gait sequence: during the stance phases he had a decreased maximum of dorsal flexion. He has limited hip extension in the stance phase. The knee extension is maximum at the end of the swing phase.

Modified gait types:

Table 4: Possibility of Completing Different Gait Types at Initial Examination

Tip Toes (S1)	Possible with slight difficulty.
Heel walking (L5)	Possible with slight difficulty.
Backward walking (Glute muscles)	Limited but possible.
Sideways walking (Abductors & Adductors)	With difficulty because of positive Trendelenburg.
Squats (L3/4)	Small squat possible.
Tandem walking	Possible but with bad stability.

Movement pattern examination

Analysed according to Professor Janda's movement pattern types.

To examine the movement patterns, the patient remained undressed and I gave him minimal verbal clues about how the movement should be completed optimally. I also did not touch the patient as this could be facilitatory and disrupt the movement.

Hip extension –

Right lower limb: There is co-contraction of the glutes, homolateral erectors and hamstrings. His hamstring muscles were overactive and so these activated first with co-contraction of the homolateral erector muscles. He then activated the gluteal muscles last. There was hyperactivity of lumbar area which can indicate hypoactive oblique muscles. Upon instruction, the patient was able to activate the glutes first and decrease movement in the trunk area consequently improving the movement pattern.

Left lower limb: The movement synkinesis was mostly the same as on the right side, with slightly better activation of the gluteal muscles during the start of the movement. The ROM was 10 degrees making the hip extension ROM 5 degrees greater than on the right side.

Hip abduction –

Right lower limb: His movement was combined with flexion of the hip indicating an active iliopsoas. The trunk rotated dorsally but there was no rotation of the hip. Elevation of the pelvis in cranial direction – area between ribs and pelvis decreases so quadratus lumborum and iliopsoas active. Overactive tensor fascia latae (TFL) on this side as well as minimal proper spinal stability.

Left lower limb: This side showed a better movement of the hip with slightly less flexion of the hip and less elevation of the pelvis in a cranial direction. There was flexion in the knee. After explanation of the correct movement pattern, the patient was able to complete the movement in a more optimal way with less flexion in the hip area and a more stable trunk.

Trunk curl up -

The patients pelvis moved into an anterior tilt with this movement. We can observe diastasis of the *m. rectus abdominis* as well as a poor activity of the *m. oblique abdominis*, as the abdominal wall expands to the sides. After instruction to contract his abdominals before the movement, he was able to slightly improve the diastasis and abdominal activation but not by much.

When completing the movement with flexed hips and knees, the diastasis decreased but we could still see minimal *m. oblique abdominis activity.* Flexion of only one hip at a time, caused the contralateral side of the abdomen to expand. When analysing the patient during coughing, a good contraction of the abdominal wall can be seen.

Anthropometry

Table 5: Length of the Lower Limbs at Initial Examination

Lower Limb Length Assessment	From	To	Left (cm)	Right (cm)
Whole Lower Limb	Spina Iliaca Anterior Superior (SIAS)	Medial Malleolus	89	90
	Trochanter Major	Lateral Malleolus	82.5	83
Thigh	Trochanter Major	Lateral part of the Knee	41	42
Tibial	Medial part of the Knee	Medial Malleolus	46	45
Fibular	Fibular Head	Lateral Malleolus	44	43

I did not do the anthropometric measurement of the foot (from heel to toe) because of the patients severe hallux valgus. In general, his whole left leg was shorter by 1cm than the right leg. At a younger age, he had fractured his left femoral bone so this could be the reasoning for the shorter left limb. The right crura is shorter than the left side and this is where his Achilles tendon was torn and sutured.

Table 6: Circumference of the Lower Limbs at Initial Examination

	Lower Limb Girth Assessment	Left (cm)	Right (cm)
Proximal Thigh	1cm below gluteal fold	55	54
Mid-thigh	10cm above the patellar	46	45
Knee	the level of mid-patella	39.5	39.5
Calf	the maximum circumference of the calf	36	34.5
Ankle	at the level of the malleoli	25	25
Foot	the level of metatarsophalangeal heads	25.5	26

For all circumferences of muscular areas, there is hypertrophy on the left side compared to the right. However, the measurements of the joints, except on the foot region are the same. The main difference of muscular areas is seen at the calf and thigh region.

Goniometry

Table 7: Active goniometry of the Lower and Upper Limbs at Initial Examination

JOINT	MOVEMENT	LEFT (°)	RIGHT (°)
HIP	Flexion	100	95
	Extension	10	5
	Abduction	20	20
	Adduction	10	10
	Internal Rotation	10	0 (Pain)
	External Rotation	25	20
KNEE	Flexion	115	120
	Extension	0	0
ANKLE	Dorsiflexion	15	10
	Plantarflexion	40	35
SHOULDER	Flexion	165	155
	Abduction	140	145
	Internal Rotation	60	25 (Pain)
	External Rotation	75	70
ELBOW	Flexion	135	135
	Extension	0	-30
	Pronation	85	80
	Supination	85	80

These measurements were executed with a universal goniometer and tested with active movements. I tested the goniometry of the most important movements for the patient.

- Upper extremities – In the left upper extremity, he had full ROM. On the right upper extremity, the shoulder had a decreased ROM as the movements caused pain. He has permanent pain in the area of acromioclavicular joint and long bicep tendon so it was important to test the ROM here. Internal rotation was very painful for him and this is why there was a large limitation here. There is a blockage in his elbow which resulted in an increased amount of permanent flexion on his right side so there was restricted elbow extension. Pronation and supination in both elbows was done without restriction.
- Lower extremities – The internal rotation of the right hip joint was 0 degrees as this movement caused pain for the patient. When testing his knee flexion, the position was adapted slightly and the knee flexion was tested with the patient on his back rather than in prone position as his slightly shortened quadriceps muscles limited the movement into flexion. Flexion of his left knee is more restricted (5 degrees less). On his right ankle, there was both limited dorsiflexion and plantarflexion (the ROM was 5 degrees less on the right ankle for both movements), this was the side where his Achilles tendon was ruptured.

Muscle strength test

Table 8: Strength of Muscles by Manual Muscle Test at Initial Examination (According to Professor Vladimir Janda)

Joint Movements	Left leg	Right leg
Hip Joint	-	-
Flexion	4+	4
Extension	4	3+
Abduction	4	3+
Adduction	4	4+
External Rotation	4	3+
Internal Rotation	Pain	Pain
Knee Joint	-	-
Flexion	4+	4+
Extension	4+	4+

His abdominal muscles received a strength grading of 3. It was not possible to test trunk extension as this movement caused too much pain.

Overall the strength of the patient was really good, most of the muscles on his left side received a higher strength grading than the right side.

Muscle shortness

Table 9: Muscle Shortness Test of Lower Extremities at Initial Examination (According to Professor Vladimir Janda)

Muscles	Left	Right
Piriformis	1	1
Quadriceps (Rectus femoris)	1	1
Hamstrings	2	2
Iliopsoas	0	2
Soleus	1	1
Gastrocnemius	0	0
Adductors	1	1
Tensor Fascia Latae	1	1

0 – Normal Muscle Length, 1 – Slight Shortening, 2 – Muscle shortening

The only difference between muscles on the left and right side was seen with the *m. Iliopsoas,* which was shorter on the right side. I did not test the Quadratus Lumborum as it resulted in pain and the position for testing was not optimal considering the patients back pain.

Palpation and Inspection

Kibler's fold: Restriction in the lumbar area as well as lower thoracic region.
It is not possible to perform on the right side. Slightly less restriction on the left side.

Skin mobility and elasticity: Restriction in the lumbar area specifically on the right side.

Skin temperature: Increased temperature on the lumbar and sacral area.

Fascia: Moveable lateral fascia in the thoracic area on both sides. Restriction of lumbar and sacral fascia especially in the caudal direction.

Muscle tonus: Hypertonus of *m. piriformis* and *m. gluteus maximus* on the right side. Once pressure was applied to the *m. gluteus maximus*, it relaxed. Increased tension of the left spine extensors in the thoracolumbar region.

Percussion: There was no pain with percussion on the limbs and also on the chest.

Pain and sensitivity: Palpation causes contraction and pain for the patient in the lumbosacral region in all directions. Sensitive piriformis on both sides.

Other: There was confirmed diastasis of the *m. rectus abdominis.*

Fibrotic tissue could be felt on his right Achilles tendon and there was a visible scar.

If the tendon of his *m. biceps brachii long head* was palpated there was a feeling of dislocation of the tendon from the sulcus.

Breathing Pattern Examination

This examination was done by palpating the lower chest and some of the auxiliary respiratory muscles. I monitored the movement of the ribs and the patient has an abdominal breathing pattern where the diaphragm works mostly. Breathing is physiological with ventrodorsal expansion of the chest and ventral migration of the sternum. His ribs expanded laterally and there was slight elevation of the chest during inspiration. When he is deep breathing, we can see more of an upper chest breathing pattern. The patient can actively and voluntarily contract the abdominal muscles. Breathing does cause some pain.

Neurological Examination

Superficial sensitivity of the lower extremity: This was tested by light touch. The patients sensitivity was in order and even on both sides.

Deep sensation examination: This was examined by testing the movement sense and position of the hallux. There was slightly decreased proprioception on both sides.

Deep tendon reflexes: The patient had no problem with his reflexes when I tested them using a reflex hammer. All of his deep tendon reflexes were in order except for the right Achilles tendon reflex which has hyporeflexia. This is the side that his Achilles tendon was sutured.

Neuropathological reflexes: All neuropathological reflexes were negative, indicating that a physiological response was observed. These include Babinski, Hoffman, Clonus, Chaddock test, Tromner and Oppenheim.

Provocative tests: Both Lasegue and reverse Lasegue were negative on the left side. On the right side, Lasegue was negative but reverse Lasegue was positive. The pain during the right reverse Lasegue test correlates with the patients description of pain that spreads down the right side. It can also be related to the shortening that is present in the *m. iliopsoas* and *m. rectus femoris*.

Table 10: Lumbosacral Nerve Irritation Tests at Initial Examination

Examination	Left	Right
Lasegue	Negative	Negative
Reverse Lasegue	Negative	Positive

2.5.1 Short-term rehabilitation plan

I completed 10 days of rehabilitation with Mr. P.M., on some days I was with the patient twice (once in the morning and once in the afternoon). The first 2 days consisted of subjective and objective examinations in the morning and then beginning with the first stages of rehabilitation with the patient in the afternoon hours. During the hospitalization, the patient received 10 analgetic infusions. As the patient received his analgetic infusions, he was in less pain so it was easier to exercise and we could adapt the exercises to make them more specific, challenging and effective. Our rehabilitation plan was based on the examinations that I completed and also recommendations set by the doctor. The therapy therefore had the main goals aimed to increase the strength of the abdominals, trunk and gluteal muscles to improve his spinal stabilization, improve movement patterns and stretch the shortened muscles. An essential part of his pain management was to decrease his neurological symptoms. I used manual stimulation in order to increase his proprioception and help with sensorimotor training. It was also important to educate the patient about the self-therapy methods that he could use at home to release his back, as his time in the department was too short to completely improve his musculoskeletal situation.

My patient was very cooperative and motivated to exercise. After a short time, he was able to complete all movements by himself and moving into different positions was achieved with more ease.

The main aim of rehabilitation in the initial stages was to control the patient's pain and start the process of strengthening and stretching his muscles to ensure that he has a period of remission from his back pain for a longer time. Demonstrating correct movement patterns was also important and ensuring that the patient's posture was optimal for keeping the best position for his back.

Therapeutical exercises (kinesiotherapy) that I incorporated:

- Active exercise for lumbar spine stabilisation and deep stabilisation system activation (in lying, sitting, kneeling, standing position).

- Stretching exercises to lengthen and relax the shortened muscles (*m. rectus femoris, hamstrings, m. piriformis, m. iliopsoas, adductor muscles of the hip, pectoral muscles and paravertebral muscles*).

- Strengthening of weak muscles (*abdominals, gluteal, quadriceps, scapula muscles…*) using body weight as well as resistance bands, light weights and varied sizes of overball.

- Sensorimotor exercises (using unstable surfaces and balance equipment). Before training the sensorimotor exercises, it is important to do basal stimulation techniques to increase proprioception. This can be done by massaging the foot. Another method is to use a rough ball with spikes under the sole of the foot for about 5-10 minutes or use the roller board that has spikes on. During the training we instruct the patient to make a 'short foot' which activates the intrinsic muscles of the feet. Activation of these muscles creates more stability by the reflex activation of the pelvic floor and hip muscles.

- Gait re-education to decrease the stiffness of the gait. Training to improve the arm swing to allow for more stability.

- Aerobic exercise (stationary bicycle).

- Brunkow and Mckenzie method.

- Posture correction

Figure 8: Basal stimulation techniques and sensorimotor training with the patient (Informed consent given by the patient for the pictures)

Manual techniques

- Soft tissue methods for stretching of skin, subcutis and fasciae.
- Soft tissue techniques in the thoraco-lumbo-sacral area and the gluteal area in order to relax hypertonic muscles.
- Lumbar spine traction to release joint blockages (mobilizations were not done as this is not ideal due to the degeneration occurring in the spinal structures).
- Post Isometric Relaxation (PIR) by Lewitt (*m. rectus femoris, hamstring muscles, m. piriformis, m. iliopsoas, adductor muscles of the hip, and pectoral muscles*).

Modalities

- Thermotherapy: Hot pack (Vulcanpack) placed over the lumbar area twice a day for 20-30 minutes. This modality was used before exercise and manual techniques in order to make the area less stiff and allow for more movement.
- Electrotherapy: A dipole vector current in the lumbar area was used daily for 15 minutes at a nearly motoric intensity with the following parameters:

  - Intensity: 30 mA increased to 34mA
  - over the course of therapy
  - Carrier frequency = 4.0 kHz
  - Basic Frequency = 100Hz
  - Maximum frequency = 100 Hz
  - Rotator mode = auto
  - Rotation time = 8 s

Figure 9: Dipole Vector Electro-therapy (Informed contenst given by the patient for the picture)

Back school, ergonomics and education

Back school was an important part of the rehabilitation as the patients problem is chronic and it is essential that he is able to manage his pain and spine health himself. When movements are performed in the most efficient manner, less stress is put on the back and the result is a longer remission period.

- Teach the patient how to change positions in the correct manner.

- How to perform Activities of Daily Living (ADL's).
- Training for the correct posture in standing, sitting, lying, bending.
- Training how to lift heavier objects.
- Teach him abdominal and spinal muscle activation techniques.
- Stretching of spinal erectors.
- Educate the patient on how to perform autotherapy, also explain the benefits of each exercise.
- Sport ergonomics (volleyball).

Over the course of his hospitalization, it was important to ensure that Mr. P.M puts this information into practice.

2.5.2. Method of rehabilitation

In St Anne's Inpatient Rehabilitation Department, the method of rehabilitation is divided into 2 separate exercise sessions per day. After each day the patient's progress is recorded and taken into account so changes and improvements can be made to the exercise units for the next days:

Unit 1) In the morning hours, before lunch. Mr. P.M. was most active so his morning exercise unit focused on strengthening muscles that were weak according to the examination, but also improving his overall fitness. We trained gait and educated the patient on autotherapy.

Unit 2) After lunch the focus was on manual techniques including soft tissue mobilization, PIR and traction. We also trained his sensorimotor system.

This method of rehabilitation is just a general guideline and was slightly adapted in the first few days when I was completing the examinations with the patient. The examination was mostly completed in the morning and the afternoon session focused on exercising and manual techniques. We also adapted this plan according to the time that I had with the patient.

I created 2 exercise units that I based my daily rehabilitation on and adapted them slightly by adding different types of equipment like a gym ball, TheraBand or light weights. I also created an autotherapy protocol for the patient.

Everyday Mr. P.M. received a session of electrotherapy and used thermotherapy before exercising and receiving manual techniques. Thermotherapy using the Vulcanpack was placed on the patient's back for 30 minutes before moving to the exercise room. The patient was also responsible for ensuring that he used the hot pack at least

once a day. Electrotherapy was administered according to the parameters mentioned in the previous chapter and the intensity was increased subjectively according to the patient.

2.5.3. Realization of rehabilitation procedures by the author

Session 1 – 10th October 2022 (Monday) – Patient Examination

I was first introduced to my patient on this day, at 10:00am. I was accompanied by my tutor, Mgr. Veronika Mrkvicová. At first we just did a general exercise unit that mostly included movements to analyse his abilities. We tested his ability to stand, move from tip toe to heels, stand on one foot, flexing forward and to the sides and then analysed his movement into lying position. The patient was happy to cooperate even though he expressed feeling a considerable amount of pain.

Today's rehabilitation goals: start the kinesiological exam and start a general exercise unit for chronic lower back pain. The examination focused on the patient anamnesis so that we could have a deeper understanding about his personal, family, social and medical history. Do the posture and pelvic assessment, spine dynamic tests and gait examination. Complete a palpation, breathing and movement pattern examination.

Therapy proposal:

- Treat the soft tissue in the thoraco-lumbo-sacral area in the caudal and cranial direction.
- Basic stretching and strengthening exercises

Therapy notes:

The examination was not complete so the exercise unit was based on general lumbar spine rehabilitation and therapy was not specific to the muscles that Mr. P.M. experiences weakness and shortening with.

- Active exercise for lumbar spine stabilisation and the deep stabilisation system activation including the diaphragm and transversus abdominis activation. These were done in supine lying position with the legs bended to provide a more comfortable position for the lower back.
- Stretching exercises (*hamstrings, piriformis, adductor of the hip, pectoral muscles, and lumbar paravertebral muscles*).

- Strengthening of muscles around the lower back, specifically the abdominal and gluteal muscles

- Gait re-education to add the natural movement of the upper limbs

After the examinations and therapy, Mr. P.M. was feeling tired.

Session 2 – 11th October 2022 (Tuesday)

I saw my patient in the morning at 09:00.

Today's rehabilitation goals: Complete the kinesiological examination focusing on goniometry, limb length and circumference, muscle strength and shortening. Start therapy according the results from the examination and using the 'Exercise Unit 1' which can be found in 'Appendix A'. Ask the patient about his pain according to the visual analogue scale (VAS).

VAS results: At rest pain is a 3/10. During exercise or movement the pain is 7/10.

Therapy proposal:

- Treat the soft tissue in the thoraco-lumbo-sacral area. Treat the fascia in a cranial and caudal direction. Do ischemic compression of trigger points in piriformis and gluteal muscles as well as the paravertebral muscles

- Active exercise for lumbar spine stabilisation and activation of the deep stabilisation system now including the pelvic floor muscles too. Do these exercises in supine, prone and side lying positions. Use a gymball in the supine lying position

- Stretching exercises (*hamstrings, piriformis, adductor of the hip, rectus femoris and iliopsoas, pectoral muscles, and lumbar paravertebral muscles*)

- Strengthening of weak muscles (*abdominal, gluteal, hip abductors and quadriceps femoris muscles*)

- Gait re-education

- Back school: demonstrate the correct sitting and standing position, good form of sitting up and lying down in the bed. Speak about ergonomics: how to select optimal bed, pillow and chair.

Therapy notes:

Completion of the examination took a bit of time and the patient was feeling tired after but he was really cooperative throughout. We had a break and then we worked with the exercise, manual techniques and therapeutic modalities. From the information I gathered in the examinations completed in the morning, it was possible to do exercises that were focused on the patients musculoskeletal deficits.

- Active exercise for lumbar spine stabilisation included pelvic tilts, pelvic bridging with feet on the bed first and then feet place on a cylindrical shaped overball. After this we did alternating hamstring stretches followed by alternative knee to chest exercise.

- Gait re-education – the focus was to try to add the natural movement of the upper limbs. I explained to the patient that a proper arm swing in his gait is important for making the shifting of weight smoother and so allowing for greater balance while walking. The first drill that we did was swinging to arms around the body and then practicing the swinging of the arms back and forth. In the forward position I instructed him to have his hands facing his face and in the backward position they needed to face toward the ceiling. After a few repetitions we added in movements of the legs, lifting one leg alternatively with each arm swing.

- To teach the patient back school, I demonstrated the correct sitting and standing position, as well as the good form of sitting up and lying down in the bed. We also spoke about ergonomics and how he should select an optimal bed, pillow and chair.

Session 3 - 12.10.2022 (Wednesday)

My patient was already starting to feel an improvement and feel less pain since he had received his second analgetic infusion today. This meant that we could start to add new exercises and also increase their difficulty.

Today's rehabilitation goals: Complete an exercise unit still focusing on more basic exercises and improving on the exercises we did yesterday.

Therapy proposal:

- Same as the previous day but increasing the number of repetitions

- Teach the patient autotherapy

- PIR (*m. rectus fem., hamstrings, piriformis, iliopsoas, adductor of the hip, pectoral muscles*)

- Lumbar spine traction to flexion in prone lying position

- Increase the intensity of the electrotherapy

- Back school: Teach the correct way to move into a kneeling position in order to use the mat on the floor for exercising. Demonstrate the correct way to lift and carry objects

Therapy notes:

- Soft tissue techniques focused on the thoraco-lumbo-sacral area as well as the gluteal area. I used ischemic compression of trigger points in piriformis and gluteal muscles and then did post isometric relaxation of the m. rectus femoris, hamstrings, piriformis, iliopsoas, adductor of the hip, pectoral muscles

- Lumbar spine traction in a prone lying position. It was done into a flexion position.

- The autotherapy programme that I taught the patient can be found in Appendix A below as 'Autotherapy'

Session 4 – 13th October 2022 (Thursday)

Mr. P.M. was feeling a greater improvement today so we could include aerobic training. We also did a group training session with 2 other men who had undergone lumbar spinal surgery. The second session was individual.

Today's rehabilitation goals: Start with aerobic exercise as well as sensorimotor training and continue to advance the patients therapy.

Therapy proposal:

- Aerobic training

- Group exercise training

- Facilitate the lower extremity

- Sensorimotor training

- Teach the concept of short foot

Therapy notes:

- Aerobic training on the stationary bicycle for 10 minutes at 40 Watts.

- 30 minutes of exercise in the group that was focused on a general strengthening of the body while making sure the movements were indicated for lumbar spine patients (training upper limbs, spine and lower limbs). We used the gymball in supine lying position as well as a TheraBand for increased intensity.

- With the patient in a lying position, I rolled a spiky ball along the soles of his feet and then massaged the core foot muscles to facilitate the lower extremity. Facilitation was done for 15 minutes.

- The patient then sat on the bed and we learnt how to train short foot by using the toes to move a small towel toward the foot. After this I put pressure on his knee and he was instructed to keep the position of the short foot.

- We started training the sensorimotor system by using unstable surfaces and balance equipment at the sensorimotor parallel bars pavement.

Session 5 – 14th October 2022 (Friday)

Mr. P.M. was feeling more mobile and happy with his therapy progress. He was finding it easier to move around the department with less pain.

Today's rehabilitation goals: The goal for today is to progress to a kneeling position for the spinal mobilisation exercises and start to use the advanced exercise unit found in the attachments section of this paper. Ask patient about his pain according to the visual analogue scale (VAS).

VAS results: At rest pain is a 0/10. During exercise or movement the pain is 4/10.

Therapy proposal:

- Aerobic training

- Active exercise for lumbar spine stabilisation as well as the deep stabilisation system activation

- Spine mobilisation exercises in a kneeling position

- Strengthening exercises with added resistance
- Gait training on the stairs
- Sensorimotor training
- Back school: the correct way to kneel and use the mat for exercise at the floor, the correct way to lift and carry objects
- Teach the patient lumbar spine autotraction

Therapy notes:

- We did active exercise for lumbar spine stabilisation and deep stabilisation system activation adding exercises in a sitting position using a gym ball.
- Spine mobilisation exercises in a kneeling position too by doing flexion and extension of lumbar and thoracic spine (Cat-Cow position) as well as extending one of the limbs out and then doing abduction of each hip.
- We completed the strengthening and stretching exercises with an added TheraBand and added more upper extremity exercises.
- Sensorimotor training using a spiky balance air pad and wooden balance ball.

Session 6 – 15th October 2022 (Saturday)

I went at 09:00 and trained with the patient for one longer session instead of 2 separate sessions.

Today's rehabilitation goals: Complete a longer session in order to increase endurance and to allow the patient to rest for the afternoon.

Therapy proposal:

- Aerobic exercise on the bike for 15 minutes at 40W
- Active exercise for lumbar spine stabilisation and deep stabilisation system activation only in supine and side lying position
- Stretching and strengthening exercises
- Gait retraining, tandem walking and steps training

Therapy notes:

Mr M.P. was in a good mood and he was happy to have the rest of the day to rest. He was very motivated today and enjoyed training the gait as he said he was feeling more stable.

Session 7 – 17th October 2022 (Monday)

Mr. P.M. was feeling a lot better starting the new week. His previous week of rehabilitation was successful and his analgetic treatments have been positive resulting in a significant reduction of his pain. This meant that in the new week before his discharge we could focus on more specific exercise that were more challenging and involved more transfers into different positions.

Today's rehabilitation goals: Repeat the 2 scale test to evaluate progress. Start with the 'Advanced Exercise Unit' found in the Appendix A below. Increase the intensity of the aerobic training to 50 Watts for 10 minutes and it should be done twice a day.

2 scale test results: Improved from +6kg on the left side to +2kg.

Therapy proposal:

- Kaltenborn spine mobilization exercises
- Manual techniques (Ischemic compression, PIR, traction)
- Teach the patient lumbar spine autotraction
- Sensorimotor exercises

Therapy notes:

- We did active exercise for lumbar spine stabilisation and deep stabilisation system activation adding exercises in a sitting position using a gym ball.
- Strengthening of weak muscles with the use of the TheraBand, gym ball and add in some light weights.
- Kaltenborn spine mobilisation exercises in kneeling position using flexion and extension of the lumbar and thoracic spine.

Session 8 - 18th October 2022 (Tuesday)

Today's rehabilitation goals: Improve how the patient performs the Kaltenborn auto-mobilisations and redo the same therapy from yesterday. Consider the ergonomics of volleyball.

Therapy proposal:

- Same as the previous day
- Back school: Reminder of the correct way to lift and carry objects and discuss sport ergonomics for volleyball.

Session 9 – 19th October 2022 (Wednesday)

In the morning at 09:00 we completed the final examination as it was Mr. P.M.'s last full day in the department.

Today's rehabilitation goals: Complete the final kinesiological exam in the first session. The second session should focus on doing an exercise unit that the patient can continue with at home. Complete two round of aerobic exercise at an increased intensity.

Therapy proposal:

- Active exercises for lumbar stabilisation and the deep stabilisation system activation
- Strengthening and stretching muscles
- Manual techniques
- Sensorimotor training
- Reminder of autotherapy techniques (PIR and Traction)

Therapy notes:

- After the examination, he spent 10 minutes on the stationary bicycle at an increased intensity of 60W and I asked my patient to complete another 10 minutes on the bike before our afternoon training. This gave us more time for the exercise unit and sensorimotor training and also gave a sense of

responsibility to Mr. P.M. as when he leaves the department his exercise training will be up to him.

- Strengthening of weak muscles was done with the use of a TheraBand as he has one of these at home.

- We again focused on active exercise for lumbar spine stabilisation and the deep stabilisation system activation in supine and prone lying position and in sitting position using a gym ball.

Session 10 – 20th October 2022 (Thursday)

Today's rehabilitation goals: Patient education before discharge.

Mr. P.M. was reminded of everything that we taught him in back school and of the autotherapy that he can do when he is at home. He was told to keep exercising to strengthen the muscles that we found were weakened and to also stretch the shortened muscles to keep his posture optimal for his spine health. He was then discharged.

2.4.2 Kinesiological examination and assessment of the patient at the completion of comprehensive rehabilitation (19.10.2022)

Pain according to the visual analogue scale (VAS)
At rest pain is a 0/10. During exercise or movement the pain is 1/10.

Objective examination:

Frontal centre of gravity –
The 2 scale test

The patient had a difference of 2kg between the scale with more weight on the left side. This greatly improved by 4kg over the course of therapy.

Overall his posture improved slightly, there was less elevation in his right shoulder. He still had a slight abdominal diastasis but it improved and there was slightly more contraction of the obliques. His pelvis position improved to a more symmetrical level from both an anterior and posterior view. From the sides there was still a slight discrepancy but the pelvis torsion was less.

Mattheuis test: negative, the posture remains in a good position.

Pelvic examination

The pelvis is now in a more physiological position, with all 4 points of the pelvis as well as the iliac crests on the same level.

Iliac Crests: Same level

Posterior superior iliac spines (PSIS): Same level

Anterior superior iliac spines (ASIS): Same level

ASIS and PSIS (right side): Same level

ASIS and PSIS (left side): PSIS is slightly lower than the ASIS

Result: Mostly symmetrical pelvis

Tests of stability

- *Trendelenburg test:* Negative on both left and right. He can now stand in a stable position with less shaking and no compensation from other parts of the body.
- *Rhomberg standing positions:* No pathology – all negative (eyes closed with wide stance, eyes open with narrow stance and closed eyes with narrow stance). Closed eyes with narrow stance improved with a now stable position.
- *Movement from heels to toes:* Still possible without a loss of balance.

Spine dynamic

Flexion

- Less anterior tilt of the pelvis
- Slightly less overloading of the thoracic area

Extension

- This movement improved, as there is now a cooperation of the lumbar extensors and the abdominal muscles. There was minimal movement in the lower limbs and pelvis which was optimal.

Lateral Flexion

- This movement was now more symmetrical and was even on both sides which showed great improvement on his right side.

Rotation

- There was less pain in the lumbar area on rotation to the right so the ROM increased but overall rotation is still slightly limited.

Table 11: Spine Dynamic Tests (Initial vs Final Examination)

Test	Initial Examination	Final Examination
Thomayer	+50cm	+50cm
Schober	+4.5cm	+4.5cm
Stibor	+7cm	+7cm
Anteflexion and Retroflexion of lumbar region	Limited	Less limited
Lateroflexion to the left	13cm	14cm
Lateroflexion to the right	9cm	14cm
Thoracic rotation to the left	20 degrees	20 degrees
Thoracic rotation to the right	10 degrees	15 degrees
Otto Index Inclination	3cm	2cm
Otto Index Reclination	1.5cm	1.5cm

Gait Examination

Considering the duration of therapy, there was a good improvement in Mr. P.M's gait as he learnt to use his upper limbs more. The gait overall is still slightly stiff but there is more movement of his pelvis and this also allows increased movement in his upper limbs resulting in a more stable and confident gait. His strides still have an equal length.

Modified gait types:

Table 12: Possibility of Completing Different Gait Types at Final Examination

Tip Toes (S1)	**Possible.**
Heel walking (L5)	Possible.
Backward walking (Gluteal muscles)	Improved making it possible.
Sideways walking (Abductors & Adductors)	Definite improvement due to negative Trendelenburg.
Squats	Larger squat possible.
Tandem walking	Possible but with better stability.

Movement pattern examination

Overall there was an improvement in the movement patterns and over the course of rehabilitation, I made the patient aware of the correct patterns during exercise. I did this constantly to remind him and allow him to make a habit of it.

Hip extension –

There was a definite improvement in this movement pattern. The gluteal muscles started to activate first in order to initiate the movement.

Hip abduction –

This is still not completed in an optimal pattern, as he still slightly elevates his pelvis towards the ribs but it is less than before. There is less flexion in the hip and decreased movement of the trunk on both sides.

Trunk curl up –

The diastasis of *m. rectus abdominis* was more controllable as the patient now had an increased awareness of activating his *m. obliquus abdominis* and *m. transversus abdominis* when completing this movement. The diastasis could still be seen and was present in lateral flexion and rotations too. He did however learn to activate the muscles better. He was able to activate the oblique muscles, but they were not the 1st muscles to be activated. There is still an abdominal dysfunction with an overactive *m. rectus abdominis* and hypoactive *m. obliquus abdominis*. He can however activate the

abdominal wall well when it is done voluntarily. The abdominals were more prominent in the left lower ribs when both knees were placed in a table top position.

Goniometry

The values found in the final goniometry tests remained the same as in the initial exam. The patient however felt as though he had an increased ROM globally but he was unable to specify exactly where. ROM in the spine did improve which can be seen in the spine dynamic tests.

Muscle strength test

The strength of the hamstrings and gluteal muscles increased by half a point for both sides. This showed in his movement pattern tests as well when the gluteal muscles showed more activity.

Muscle shortening test

There was no real improvement seen here as the patient was only in the rehabilitation department for a short time, and a couple of days of stretching did not necessarily improve the muscles shortness.

Palpation and Inspection

Kibler's fold: It was now possible to gain a skin fold on both sides.

Skin mobility and elasticity: The skin was more moveable in the lower thoracic area and there was less restriction in the lumbar area in all directions especially on the right side.

Skin temperature: Even temperature throughout the back.

Fascia: There was an increase in movement of the thoracolumbar and sacral fascia in the caudal and cranial direction.

Muscle tonus: Less hypertonus of *m. piriformis* and *m. gluteus maximus* on the right side. Decreased tension of the left spine extensors in the thoracolumbar region.

Pain and sensitivity: Less pain and sensitivity when palpating the *m. piriformis* on both sides.

Other: Improvement of the diastasis of the *m. rectus abdominis.*

Breathing Pattern Examination

His breathing pattern remained the same. The patient does not feel pain anymore while breathing.

Neurological Examination

All neurological tests remained the same but there was an improvement in the provocative test. There was still a slightly positive reverse Lasegue on the right side but there was a definite improvement as the patient experienced much less pain. There was however still *m. rectus femoris* and *m. iliopsoas* shortening. The left side's reverse Lasegue test still remained negative. The Lasegue test on both sides was still negative.

Conclusion of discharge examination

Mr. P.M. was in high spirits and felt ready to return home. Our kinesiological discharge examination showed the improvement of the musculoskeletal function of the patient. The patient felt better and pointed out the positive effects that his time at the inpatient rehabilitation department had. He was enthusiastic to continue his rehabilitation plan at home. His pain had significantly decreased allowing him to make more movement's in a larger range. He was definitely more aware of his body posture and how to instil the back school into his daily life. From a physical point of view, his posture became more symmetrical but there wasn't much improvement in the weak and shortened muscles as his time in the department was simply too short to see an improvement in this.

2.6 Long-term rehabilitation plan according to the present status

General considerations

Mr. P.M. has no plans of receiving further treatment at the current time, therefore it is important that he is disciplined and consistent with his rehabilitation exercises and auto-therapy. Implementing the knowledge that he has from back school is an essential part of keeping his pain manageable.

During his time in the department, we taught him autoPIR and autotraction techniques that he could use at home. We also made sure that he was comfortable with how to do the important spinal stabilization exercises and strengthening exercises that will improve his posture and therefore improve his symptoms for a longer period of time.

Recommended activities

It is highly recommended that the patient actively keeps up with the 'Exercise Unit 1 and 2' and adopts a regular low impact activity routine. Swimming, cycling or tai chi are recommended for him. He can also continue walking regularly and participating in volleyball and football in a safe manner. He needs to take into account the back school and adapt this in his daily life when standing, transferring from bed to sitting or visa versa, performing ADL's, carrying heavy loads and driving. It would be beneficial for the patient to occasionally receive manual techniques but it is not essential. The main goal of his long-term rehabilitation plan is to continue with daily strengthening and stretching of his muscles and being mindful of his posture in different positions. He is a motivated patient that has been physically active throughout his life so I believe that he will continue the rehabilitation to some degree at home.

3 Conclusion

I am very satisfied with my experience during the rehabilitation process and working with Mr. P.M.. He was a very motivated and cooperative patient which made our rehabilitation process more effective and interesting. I feel I have deepened my knowledge in the field of lumbar spine specifically but also in general regarding how to treat spinal injuries. It was rewarding to be able to utilize the knowledge that I have gained in the three years of my studies. My understanding of how to complete a patient anamnesis has also improved and I realize how important a thorough initial examination is for providing the most effective rehabilitation. I also learnt how to adapt my patients programme individually concerning his initial examination and to observe his progress throughout the rehabilitation to make adaptations to the initial plan.

I gained knowledge in terms of how physiotherapists work on a daily basis, and that the practical work is important but also the administrative side of the job. I am grateful to my mentor; she was extremely helpful and guided me when I was uncertain about things. She taught me how to interact in a professional manner with the patient but to also form a relationship with the patient to make their therapy more beneficial and comfortable. Mgr. Veronika Mrkovicá showed me different techniques and tried to make me think of different approaches to build my rehabilitation and diagnosis knowledge.

This experience will be of great value to me during my future career in the profession.

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Appendix A

Basic exercise unit :
The unit consisted of:

1. A general warm up starting with the least painful part of body: (repeat all exercises 3x)
   - Arms above head and try to reach forward alternatively.
   - Arms in shoulder abduction and flex and extend the elbows.
   - Abdominal crunches with hands behind head.
   - Interlock fingers and reach to ceiling.
   - Hands on opposite elbows and move arms to each side.
   - Bend knee to chest and bend head to knee.
   - Bend one leg (other leg straight) and move the bent leg into adduction to stretch the hip structures.
   - FABER position of legs and push knee down to bed (Flexion, Abduction and External Rotation of hip).
   - Both legs into FABER to achieve a clam position.
   - Use a TheraBand to stretch the hamstrings with SLR.
2. Main exercise unit (repeat each exercise 10x)
   - Brunkow method.
   - Cycling in lying position.
   - Press palms against thighs (legs in bent position) and retrovert the pelvis.
   - Train abdominal obliques – reach arm to alternative knee.
   - Legs bent and perform oblique reaches – fingers to heel on the same side.
   - TheraBand for legs - placed under the heel, straighten and bend the knee while keeping arms at the side. Then put the band around the knees and do abduction.
   - Hip rotations.
   - TheraBand for arms – place it around the hands and do abduction for the scapula. First do it with palms facing in, then facing out and lastly facing down.
   - Boxing to ceiling and to the side.
   - Crunches.

Advanced exercise unit:

In supine position:

- Pelvic tilts.
- SLR's.
- Hamstring stretch by doing SLR and using hands to stretch the leg up further.
- Hip stretch – knee to chest.
- Lumbar rotations.
- Heel slides (heels to pelvis and then straighten legs).
- Bridges with feet on floor, do abdominal bracing with this movement.

- Bridges with one foot on the floor and the other foot elevated.
- Bridges with feet on an oval gym ball.
- Bridge and abduct knees with resistance band.

In prone position:

- Lie on stomach then place weight on elbows and then press up.
- Alternative hip extensions.

Quadruped position:

- Cat-cow spine flexion and extensions.
- Circle pelvis.
- Side flexion by moving pelvis towards ribs.
- Lift arms alternatively and do abdominal bracing.
- Lift legs alternatively and do abduction.
- Opposite leg and arm lifted.
- Prayer stretch (relax onto legs with arms stretched).

Include any arm exercises with weights/TheraBand.

Self-therapy:

- Pelvic tilting – move the pelvis into an anterior and then posterior tilt. Repeat this 10 times twice a day.
- Gluteal contractions – lie prone and contract the gluteal muscles without anteversion of the pelvis. In the advanced stages, lift one leg into extension and hold.
- Piriformis stretch by placing the ankle of one leg on the knee of the other in a seated position. An alternative is to lie on the bed with both knees bent and do the same movement.
- Kaltenborn spinal mobilisations.

Name Index