

T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

**INVESTIGATION OF THE EFFECTS OF
SYNCHRONIZED AND NON-SYNCHRONIZED
TELEREHABILITATION PROGRAMS IN THE
MANAGEMENT OF CHRONIC NON-SPECIFIC
LOW BACK PAIN**

MASTER THESIS

Rayan AHMED TAWFEK, PT.

ISTANBUL-2023

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İSTANBUL-2023

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated and numbered

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Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Rayan AHMED TAWFEK



DEDICATION

I would like to dedicate this thesis to my beloved parents, especially to the greatest mother anyone could wish for Iman OTHMAN, who never stopped supporting me and supporting my academic journey.

Also, I dedicate this thesis to the one who never gave up on himself and his academic career, who kept pushing forward regardless of the mental challenges, to myself.

Rayan AHMED TAWFEK

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LIST OF SYMBOLS AND ABBREVIATIONS

AI	Artificial Intelligence
BMI	Body mass index
CNS	Central Nervous System
CLBP	Chronic low back pain
CNLBP	Chronic non-specific low back pain
CBT	Cognitive behavioral therapy
CT	Computed tomography
CR	Paper-based conventional rehabilitation
MRI	Magnetic resonance imaging
ES	Erector Spinae
Group 1	Real-time synchronized telerehabilitation program
Group 2	Pre-recording non-synchronized telerehabilitation program
Group 3	Picture aided written instructions non-supervised home exercise control group
IF	Interferential current stimulation
KT	Kinesio taping
LBP	Low back pain
MDT	Mechanical diagnosis and therapy
MFR	Myofascial release
NICE	National Institute for Health and Care
NSAID	Nonsteroidal anti-inflammatory drugs
NSLBP	Non-specific low back pain

NP	Nucleus pulposus
NPRS	Numeric pain rating system
RD	Radiofrequency denervation
ROM	Range of motion
RCT	Randomized controlled trial
RCTs	Randomized controlled trials
SE	Stretching exercises
FDA	The Food and Drug Administration
IVD	The intervertebral disc
TENS	Transcutaneous nerve stimulation
TR	Video exercise-based telerehabilitation

ABSTRACT

Ahmed Tawfek, R. (2023). The Effects of Synchronized and Non-synchronized Telerehabilitation Programs in the Management of Chronic Non-specific Low Back Pain, Yeditepe University, Institute of Health Science, Department of Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

This study aims to investigate the effectiveness of synchronized and non-synchronized telerehabilitation programs for managing chronic non-specific low back pain (CNLBP). The study included 72 volunteers with CNLBP (31F, 41M; 41.26 ± 10.97 years) admitted through an online and social media advertisement campaign between January 2023 and May 2023. A custom-made questionnaire was used to record the sociodemographic features of the participants. The pain levels were assessed using a numerical visual analog scale. The Roland Morris Disability Questionnaire and the Oswestry Disability Index were used to assess the disability status of participants. Fear of movement was assessed using the Tampa Scale for kinesiophobia. SF-12 was used to assess the quality of life. Subjects were randomly assigned into synchronized telerehabilitation group (Group 1, $n = 24$), non-synchronized group (Group 2, $n = 24$), and control digital book-based telerehabilitation group (Group 3, $n = 24$). Subjects in groups 1, 2, and 3 participated in the patient education program. Core stabilization, and stretching exercises were demonstrated to Group 1 (twice a week for a total of 12 weeks). The same exercises program was given to Group 2 as pre-recorded videos (12 weeks) and to controls as a digital book (PDF file). Our main results demonstrate that pain levels, disability status, fear of movement, and quality of life were improved at week 12 in groups 1, 2, and controls ($p < 0.05$). The post hoc Turkey test revealed superiority for group 1, followed by group 2. In conclusion, real-time synchronized telerehabilitation program is superior to a pre-recording non-synchronized telerehabilitation program in terms of pain, disability status, kinesiophobia, and quality of life. We recommend further studies considering telerehabilitation for low back pain and other health-related concerns.

Key Words: exercises, low back pain, chronic nonspecific, telerehabilitation, online rehabilitation, physiotherapy, self-management.

ÖZET

Ahmed Tawfek, R. (2023). Kronik Non-spesifik Bel Ağrısında Senkronize ve Senkronize Olmayan Telerehabilitasyon Programlarının Ağrı, Hareket Korkusu ve Yaşam Kalitesini Üzerine Etkilerinin İncelenmesi, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi. İstanbul.

Çalışmanın amacı, Kronik Bel Ağrısının Yönetiminde Senkronize ve Senkronize Olmayan Telerehabilitasyon Programlarının Etkilerini incelemektir. Çalışma, Ocak 2023 ile Mayıs 2023 tarihleri arasında online ve sosyal medya reklam kampanyası yoluyla başvuran 72 kronik bel ağrılı gönüllüyü içermektedir (31 kadın, 41 erkek; yaş ortalaması 41.26 ± 10.97 yıl). Katılımcıların sosyodemografik özellikleri yapılandırılmış bir anket kullanılarak kaydedilmiştir. Ağrı seviyeleri sayısal görsel analog ölçek kullanılarak değerlendirilmiştir. Engellilik durumu, Roland Morris Engellilik Anketi ve Oswestry Engellilik İndeksi kullanılarak değerlendirilmiştir. Hareket korkusu, Tampa Hareket Korkusu Ölçeği kullanılarak değerlendirilmiştir. Yaşam kalitesi, SF-12 kullanılarak değerlendirilmiştir. Hastalar, senkronize telerehabilitasyon grubuna (Grup 1, n=24), senkronize olmayan gruba (Grup 2, n=24) ve dijital kitap tabanlı telerehabilitasyona (Kontrol, n=24) rastgele olarak ayrılmıştır. Tüm katılımcılar hasta eğitim programına katıldılar. Güvde stabilizasyon, ve esneme egzersizleri Grup 1'e uygulandı (haftada iki kez toplam 12 hafta boyunca), Grup 2'ye aynı egzersiz programı önceden kaydedilmiş videolar olarak verildi (12 hafta boyunca) ve kontrollere bir PDF dosyası olarak verildi. Çalışmamızın ana sonuçları, ağrı seviyelerinin, engellilik durumunun, hareket korkusunun ve yaşam kalitesinin 12. haftada her iki grupta ve kontrol grubunda iyileştiğini gösterdi ($p<0.05$). Post hoc Tukey testi, Grup 1'in Grup 2'yi takip eden üstünlüğünü ortaya koydu. Bu nedenle, ağrı, engellilik, hareket korkusu ve yaşam kalitesi üzerinde gerçek zamanlı senkronize telerehabilitasyon programı ile önceden kaydedilmiş senkronize olmayan telerehabilitasyon programı arasında fark olduğunu gösteren alternatif hipotez H1'i kabul ediyoruz. Daha fazla çalışmanın bel ağrısı ve diğer sağlıkla ilgili sorunlar için telerehabilitasyonu dikkate alarak yapılmasını öneriyoruz.

Anahtar Kelimeler: egzersizler, bel ağrısı, kronik bel ağrısı, telerehabilitasyon, online rehabilitasyon, fizyoterapi, kendini yönetim.

1. INTRODUCTION AND PURPOSE

Chronic non-specific low back pain (CNLBP) is characterized by persistent pain in the lumbar region near the spine without specific underlying anatomical or pathological cause for the pain [1]. CNLBP is a multifactorial condition influenced by a mixture of biological, psychological, and socially related factors. Which makes it challenging to diagnose and manage due to its complex and heterogeneous nature. Individuals with CNLBP often experience a range of symptoms, including pain, stiffness, reduced functional capacity, and a decrease in their overall quality of living [2]. Moreover, CLBP is the biggest cause in musculoskeletal disorders for seeking healthcare and can have a substantial impact on individuals and society [2, 3, 4]. It has a relatively high relevance ranging from 3.9% to 10.2% in the general population [5]. It is estimated that approximately 85-90% of individuals with low back pain get diagnosed with non-specific low back pain [2, 97]. Affecting a significant portion of the global population, CNLBP is considered a prevalent condition with leading cause of disability in individuals younger than 45 years old and is associated with substantial healthcare costs and socioeconomic burden [5, 6] The prevalence of CNLBP can vary across different populations and studies. However, it is estimated that CNLBP affects approximately 60-70% of adults at some point in their lives [1].

The management of CNLBP typically involves a multidisciplinary approach that includes pharmacotherapy, physiotherapy, cognitive-behavioral therapy, and surgical intervention for severe cases [7].

The most effective modality is still a topic of debate, but there is more evidence in the literature favoring the use of CSE for managing pain and disability [18] and increasing quality of life [19]. Stretching exercises also play an important role in treating CNLBP [20, 21]. Moreover, providing education on pain and management has been shown to yield the best outcomes for patients struggling with CNLBP [4].

The modalities for delivering exercise therapy and rehabilitation are diverse for patients with CNLBP. For not a long time ago, conventional rehabilitation (face to face) was the only way to receive healthcare. However, due to the advancement in technology, healthcare can be delivered through various delivery channels [22]. Telephone assisted rehabilitation, real-time video call rehabilitation, pre-recorded videos, written instructors

have increasing evidences supporting its equality to the traditional rehabilitation with more convenience.

Despite the various conventional rehabilitation options available, many CNLBP patients do not pursue physical therapy, which is often necessary for their condition. This may be due to issues such as timing, financial constraints, or living in remote areas with limited access to rehabilitation facilities. Therefore, there is a growing body of research on telerehabilitation. In a randomized control trials (RCTs) published in the Journal of the National Medical Association in 2021, conducted by Afsaneh Dadarkhah et al. [22] to study the difference between remote versus in person exercises for 60 patients suffering from CNLBP. Subjects were randomly divided to one of 2 groups: the remote exercise group or the in-person exercise group. The remote exercise group received exercise guidance and instruction through online video sessions, while the in-person group had a face-to-face session with a physical therapist. Pain intensity, disability, and quality of life were assessed at the beginning of the study and after 6 weeks when the study was concluded. After 6 weeks of intervention, both the groups had significant improvements in pain intensity, disability, and quality of life with no significant statistical difference between the 2 groups. Therefore, the author suggests that conducting rehabilitation sessions through online basis, is as effective as demonstrating them through traditional conventional face-to-face sessions, to manage the symptoms of CNLBP. However, this study had a relatively small sample size with a period of only 6 weeks which doesn't help us to understand the long-term effects. In addition, this was a single study with a non-supervised telerehabilitation group, and the exercises were initially illustrated in person, which contradicts the independent nature of telerehabilitation. Hence, further research with more subjects and longer program durations is needed to further understand these results and provide more comprehensive evidence regarding the effectiveness of remote exercise instruction for CNSLBP and to determine the best medium for intervention.

Therefore, the present study aims to compare the effects of a Real-Time Synchronized Telerehabilitation Program (Group 1) Versus Pre-Recording Non-Synchronized Telerehabilitation Program (Group 2) with Pictures Aided Written Instructions Home Non-Supervised Control Group (Group 3), all conducted in a completely online environment. The hypothesis is that Synchronized Telerehabilitation will be more effective than Non-

Synchronized Telerehabilitation in reducing pain levels, disability status, and improving quality of life in individuals with CNLBP.

H0: There is no difference between real-time synchronized telerehabilitation program and pre-recording non-synchronized telerehabilitation program over pain levels, disability, fear of movement and quality of life.

H1: There is difference between real-time synchronized telerehabilitation program and pre-recording non-synchronized telerehabilitation program over pain levels, disability, fear of movement and quality of life.



2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Spine and low back anatomy

A group of bones called vertebrae stacked on top of one forming a complex structure that provides many mechanical abilities, such as support, stability, and flexibility to the body [23]. The lower portion of the spine, known as the lumbar region or low back, plays a crucial role in weight-bearing and movement [24].

2.1.1. Bones

Consisting of 33 vertebrae divided into 5 anatomical regions: cervical region which consists of 7 vertebrae, thoracic region which consists of 12 vertebrae, lumbar region which consists of 5 vertebrae, sacrum region which consists of 5 fused vertebrae, and coccyx region which consists of 4 fused vertebrae. Each region has slightly different features forming arches to support flexibility and protect the spinal cord [23, 24] (Figure 2.1).

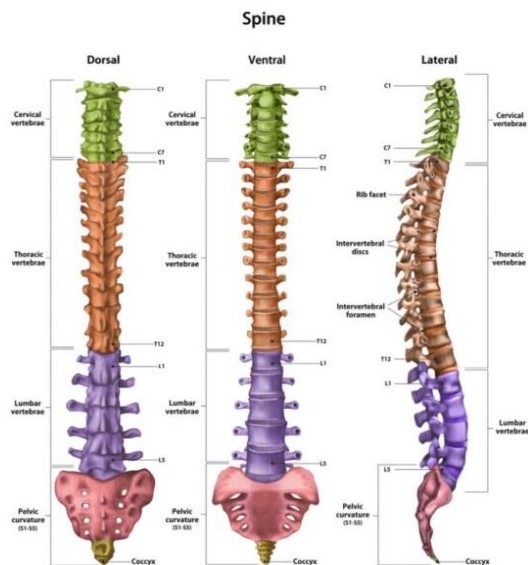


Figure 2.1. Spinal Vertebrae [25]

2.1.2. Spinal ligaments

The spine is surrounded by various ligaments that play an important role in providing stability, supporting the spine and limiting excessive movement (Figure 2.2).

Anterior Longitudinal Ligament (ALL): is a strong fibrous band that runs along the anterior part of the vertebral body from the sacrum to the shaft (C2). Preventing hyperextension of the spine and providing stability to the front of the spine, are the main functions for the ALL [27].

Posterior Longitudinal Ligament (PLL): is a thin ligament that runs along the back of the vertebral body along the spine. Preventing curvature of the spine and providing stability of the back are the main functions for PLL [28].

Ligamentum flavum: is a yellow elastic ligament that connects adjacent vertebral lamellae. It helps maintain the curvature of the spine, providing stability and reducing excessive flexion, are the main functions for ligamentum flavum [29].

Interspinous ligament: Connects the spinous processes of adjacent vertebrae. Preventing excessive flexion and providing stability to the spine are the main functions for the interspinous ligament [30].

Supraspinal ligament: Supraspinal ligament is a fibrous band that connects the tip of the spinous process of the seventh cervical vertebra to the sacrum. It provides stability and limits excessive curvature of the spine [31].

Transverse process ligaments: These ligaments connect the transverse processes of adjacent vertebrae. They contribute to the stability of the spine and limit lateral curvature [28, 29].

Capsular ligaments: Ligaments surrounds the synovial joints between the upper process and lower process of adjacent vertebrae which are called the facet joints. They provide stability and limit excessive movements [31].

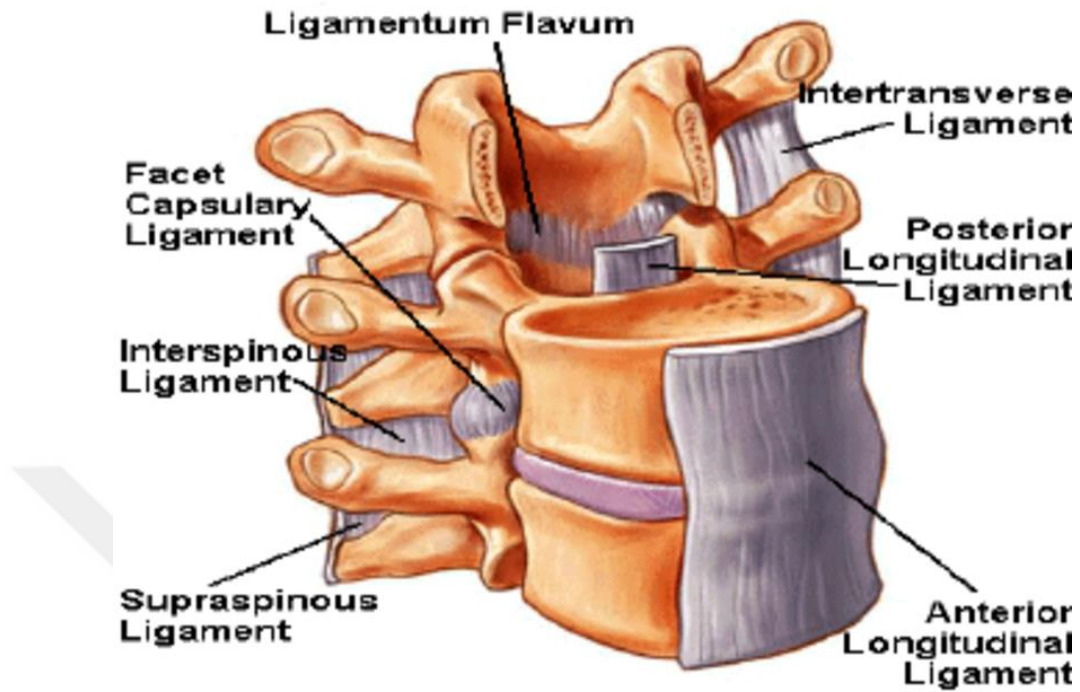


Figure 2.2. Various ligaments of the spine [26]

2.1.3. Thoracolumbar fascia

The thoracolumbar fascia is a broad, dense shape of connective tissue that covers the deep muscles in the back, which also includes the erector spinae muscles. It provides attachment sites for various muscles and acts as a stabilizer for the lumbar spine. It also helps transmit forces between the upper and lower extremity [32] (Figure 2.3).

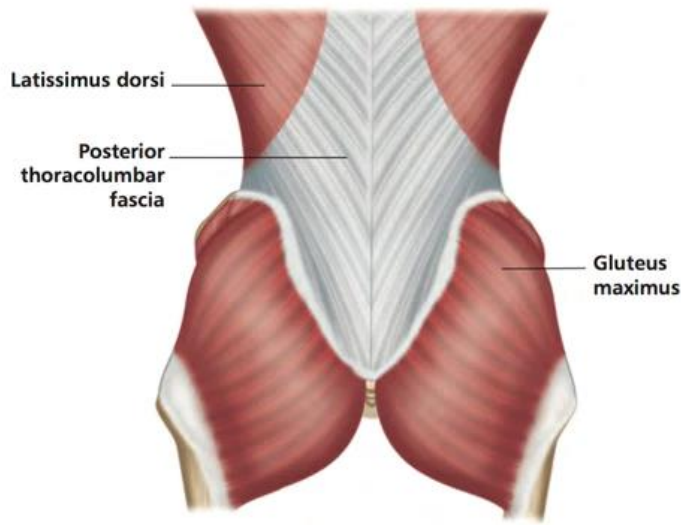


Figure 2.3. Thoracolumbar Fascia [32]

2.1.4. Muscles

In the back region there is a web of interconnected muscles comprised of main 3 groups: Superficial, Intermediate, and deep (intrinsic) muscles [33].

Deep (intrinsic) muscles

A muscle group located deep within the back, close to the spine. These deep muscles work in coordination with other muscle groups, such as the superficial back muscles and the core muscles, to provide overall stability and control of the spine during various movements [34].

Due to the complexity of the deep muscles, they can also be subdivided into superficial, intermediate, and deep layers.

Deep superficial

Splenius Cervicis: originated from T3 to T6 spinous processes into the posterior aspect of the tubercles of transverse processes between C1 to C3 [35]. The splenius cervicis muscles contract on both sides, they extend the neck. When one side of the muscles contract, lateral flexion of the head occurs. Ipsilateral contraction rotates the head and neck [36] (Figure 2.4).

Splenius Capitis muscle: starts from the lower part of the nuchal ligament between C4 and C6 vertebrae, and the spinous process of C7-T3 to the upper nuchal line and the mastoid process [37]. They keep the head in an upright position. They perform unilateral, lateral flexion and ipsilateral rotation of the head and neck (Figure 2.4).

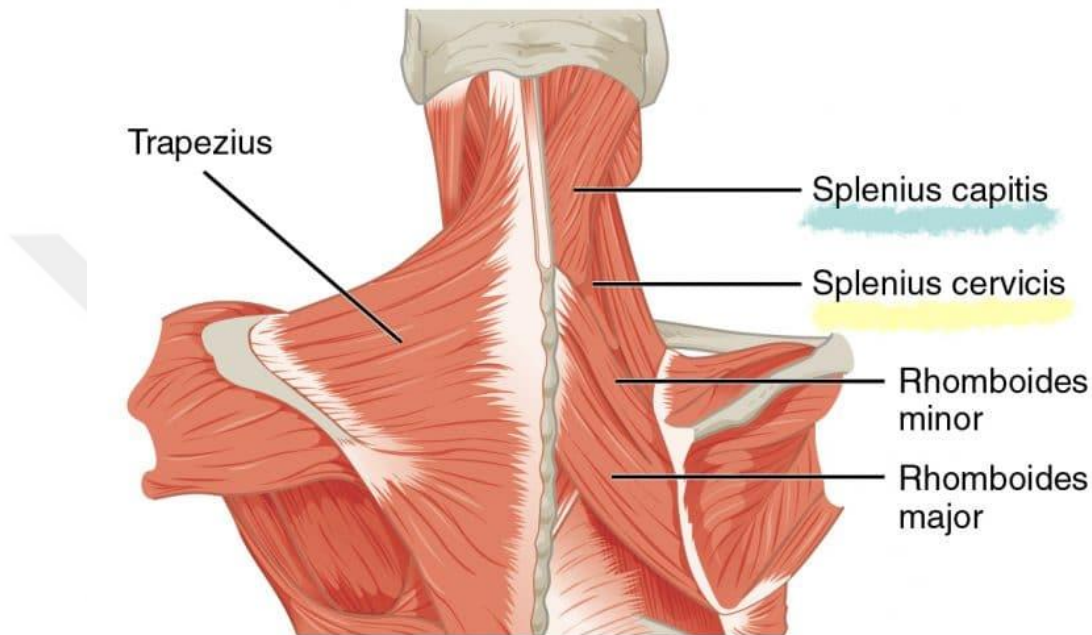


Figure 2.4. Muscles of the upper back [33]

Deep intermediate (Erector Spinae) muscles

Iliocostalis: They consist of 3 muscles based on their origin and insertion, iliocostalis cervicis, iliocostalis thoracis, and iliocostalis lumborum [38]. Working synergically with the other erector spinae (ES) muscles, their main function is lateral flexion and extension of the spine [36] (Figure 2.5).

Longissimus: are the longest, thickest, and most central ES muscles. They consist of 3 muscles based on their origin and insertion, Longissimus capitis, Longissimus cervicis, and Longissimus thoracis [39]. In addition to extension and lateral flexion function, Longissimus capitis also rotates the head [36].

Spinalis: also, consists of 3 muscles based on their origin and insertion, spinalis capitis, spinalis cervicis, and spinalis thoracis [38]. Their main function is bilaterally extending the cervical spine and head. Unilaterally spinalis capitis ipsilaterally laterally flexes and rotates the cervical spine and head [40].

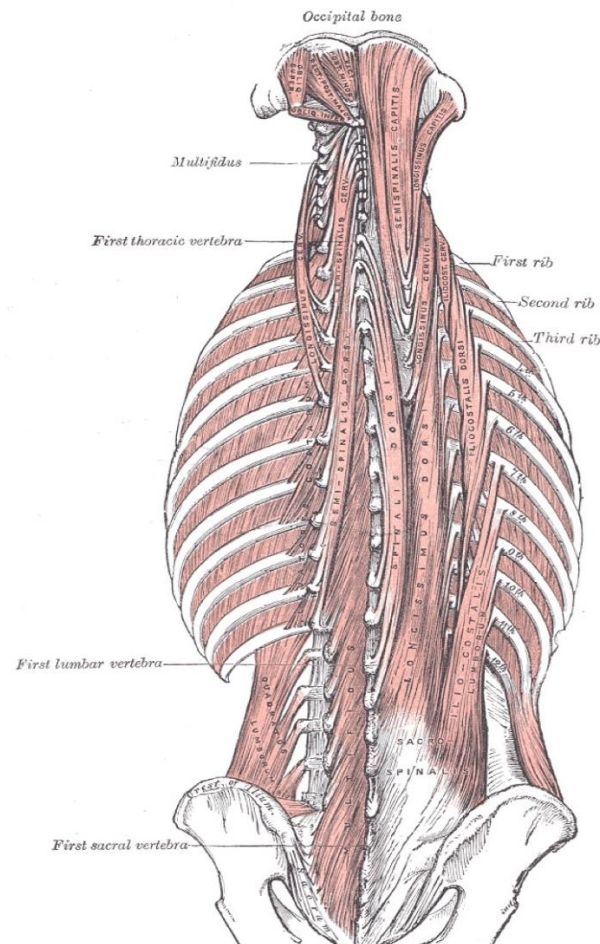


Figure 2.2. Deep back muscles [38]

Deep layers

Transversospinales

Multifidus: Multifidus is a group of triangular muscles and skeletal muscles located on both sides of the spine and holding the groove formed by the transverse and spinous processes of the vertebrae [41, 42]. By providing segmental support and control during movements, they help to stabilize and control individual segments [43].

Rotator: The rotators are a group of small muscles in the back that connect between adjacent bones. They help maintain spinal muscles and control by contributing to the rotation and extension of the spine [44].

Semispinalis muscle: divided into 3 groups according to their location: Semispinalis capitis, Semispinalis cervix and Semispinalis thoracic. The semispinalis thoracic muscle contributes to extension, rotation, and flexion of the lower back [44] (Figure 2.6).

M.semispinalis Mm. multifidi Mm.rotatores

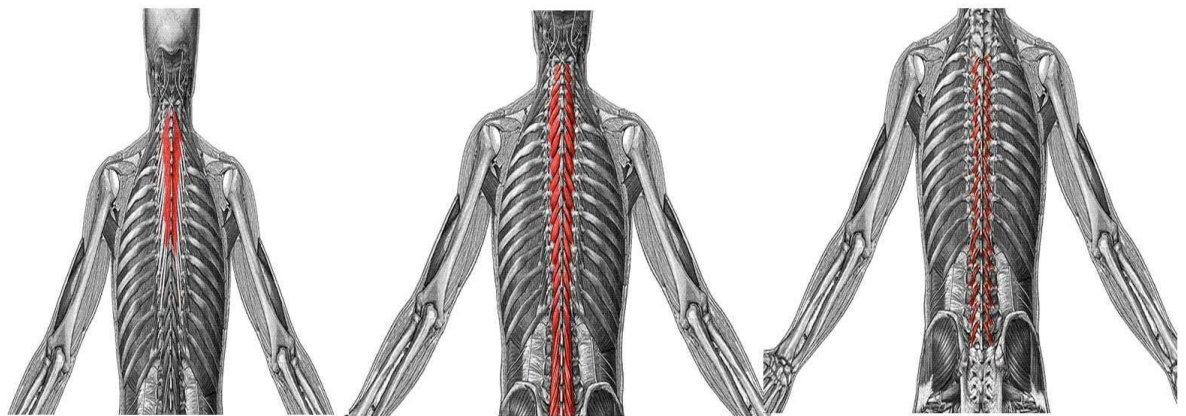


Figure 2.6. Transversospinales muscles [45]

Interspinales and Intertransversarii

Interspinales: The interspinales muscles are small muscles located between the spinous processes of adjacent vertebrae. They assist in stabilizing the spine and controlling movement between individual vertebrae [44].

Intertransversarii: The intertransversarii muscles are small muscles that contribute to lateral flexion and stabilization of the spine [44] (figure 2.7).

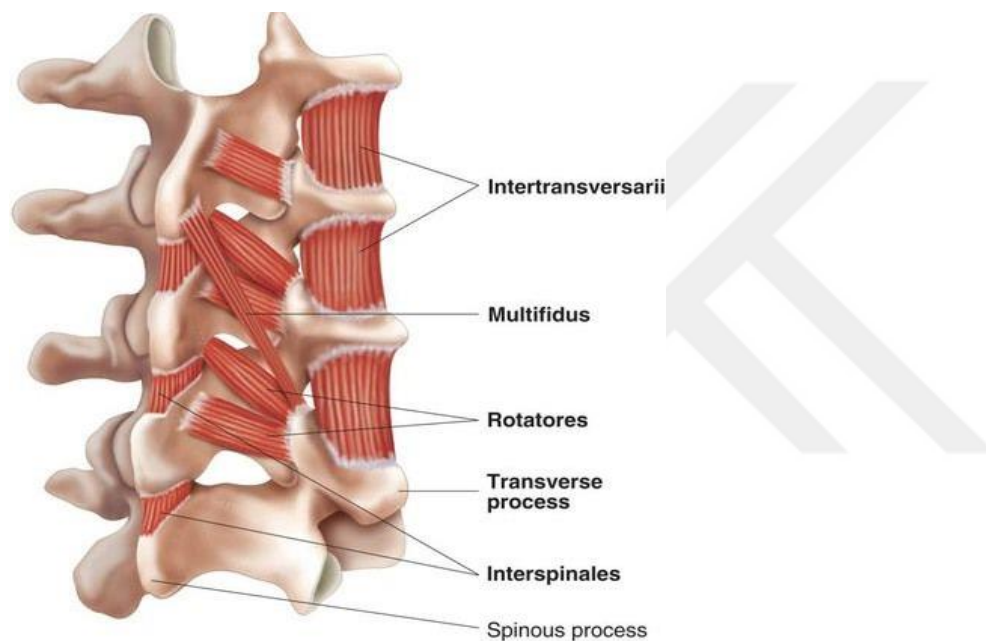


Figure 2.7. Deepest layers of back muscles [46]

Intermediate muscles

Serratus posterior

The serratus superioris muscle originates from the inferior part of the nuchal ligament and the spinous process of the upper thoracic vertebrae [23]. It is placed above the second to fifth rib (Figure 2.8).

The serratus inferior muscle originates from the spinous processes of the thoracic and upper lumbar vertebrae and attaches to the edges of the lower part of the four ribs [24]. The main function of the serratus posterior muscle is to assist in breathing by helping to support

and lower the ribs during inhalation. They also play a role in stabilization of the spine [23, 24].

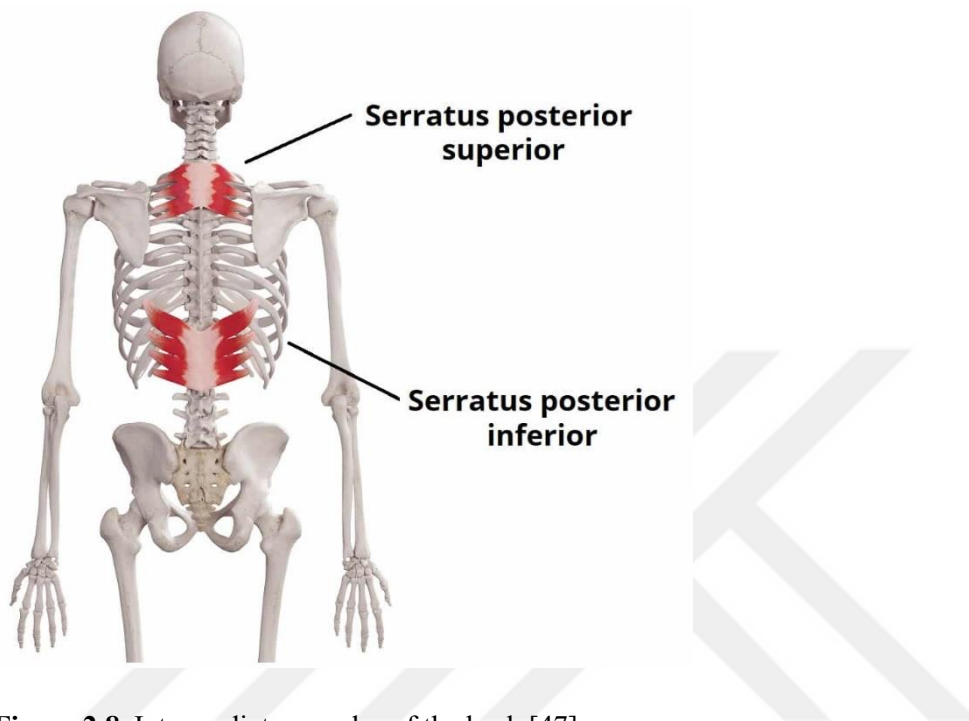


Figure 2.8. Intermediate muscles of the back [47]

Superficial (Extrinsic) muscles

Ascending (inferior), middle, and trapedescending (superior) [48]. originates in the medial third of the superior nuchal line and inserts on the lateral third of the clavicle, acromion, and scapular spine via the spinous processes of the C7–T12 vertebrae, as well as the nuchal ligament [49]. Owing to its enormous extension, the trapezius can do several things: The central section helps to retract the scapula [48], the ascending fibers contribute to the lowering of the shoulders [48], and the descending fibers raise the pectoral girdle [44]. The scapula is rotated upward when the descending and ascending fibers cooperate [48]. While unilateral contraction on the same side promotes side flexion of the neck, bilateral contraction lengthens the neck [44]. The middle fibers also support contralateral axial flexion and ipsilateral side flexion. contralateral axial rotation of the upper thoracic region [44] (Figure 2.9).

Latissimus Dorsi: derives from iliac crest, lumbar vertebrae L1–L5, thoracic vertebrae T6–T12, and thoracolumbar fascia [24]. inserts into the humerus's intertubercular

groove [24]. Owing to its enormous growth, the latissimus dorsi muscle performs a variety of tasks, such as shoulder adduction, shoulder extension, and arm medial rotation [24]. Furthermore, deep inspiration may involve the latissimus dorsi muscle [51] (Figure 2.9).

Levator Scapulae: the posterior tubercle of the transverse processes of cervical vertebrae 1–4 is where the levator scapulae muscle originates [52]. It attaches to the scapula's vertebral edge, precisely in the space between the superior angle and the spine's root [53]. By rotating the scapula downward, it mainly raises the scapula and tilts the glenoid cavity downward [54]. When the scapula is stabilized, the cervical vertebral column flexes laterally to the side as a result of the levator scapulae muscle contraction, which also stabilizes the vertebral column during rotation. The levator scapulae muscle helps elevate and rotate the scapula when the cervical spine is stabilized, which lowers the lateral angle. Furthermore, the contraction of the scapula stabilizes the joint and allows the neck to flex laterally and rotate to the same side. The cervical spine can be extended by bilaterally contracting the levator scapulae muscle [55] (Figure 2.9).

Separated into two muscles: rhomboids. Between the inferior angle and the spine, on the medial edge of the scapula, lies the Rhomboid Major, which arises from the spinous processes of the T2-T5 vertebrae [23]. The scapula is brought medially closer to the spine by its stabilization and retractions [37]. Above the rhomboid major is the Rhomboid Minor. It attaches onto the medial margin of the scapula, directly above the spine, after emerging from the spinous processes of the C7 and T1 vertebrae [23]. Its primary function is scapular retraction and stabilization, much like the rhomboid major [37]. The rhomboid major and minor muscles collaborate to facilitate a range of scapula movements, such as retraction of the scapula towards the spine, scapular downward rotation, and scapular elevation [37] (Figure 2.9).

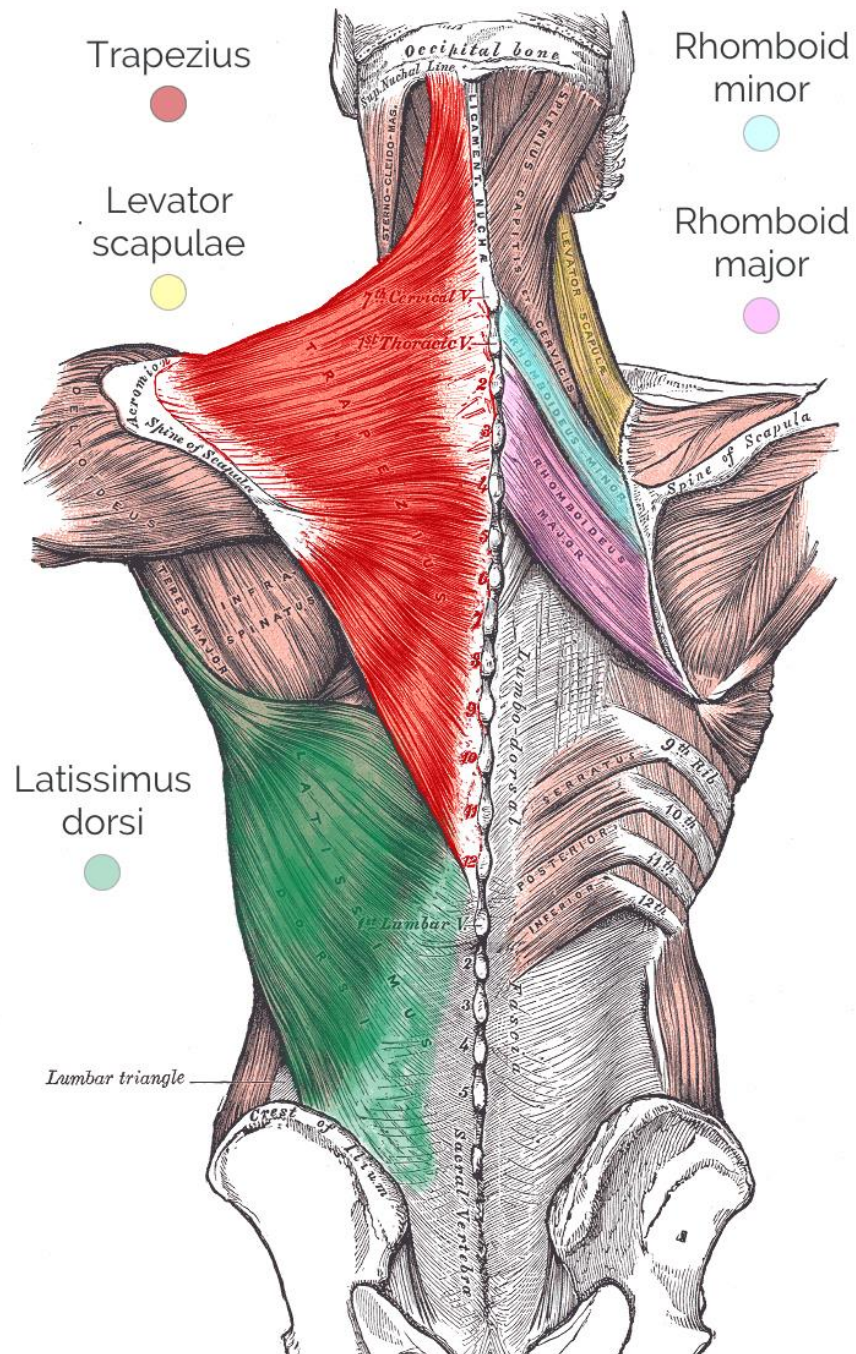


Figure 2.9. Superficial (extrinsic) muscles of the back [50]

Lumbar muscles

The quadratus lumborum attaches to the transverse processes of the lumbar vertebrae as well as the 12th rib [23]. It originates from the iliac crest. Its main purposes are to stabilize the pelvis during walking and standing, flex the trunk laterally, and extend the lumbar spine [37] (Figure 2.10).

Psoas Major and Minor: Psoas Major attaches to the Lesser trochanter of the femur as the iliopsoas tendon, and it originates from the vertebral bodies of T12-L4 and the intervertebral discs between T12-L4 [34]. The iliopubic eminence, or pecten pubis, is where the psoas minor inserts after emerging from the T12 and L1 vertebrae [24]. They (mainly the major part) act as stabilizers of the femoral head in the hip acetabulum during the initial 15 degrees of movement, ensuring proper alignment and smooth motion [57]. Unilateral contraction of the psoas muscles contributes to lateral motions, providing stability and control during sideways movements [58]. On the other hand, bilateral contraction of the psoas muscles helps elevate the trunk from a supine position, assisting in activities such as sitting up [58]. Additionally, the psoas muscles work in coordination with the hip flexors to flex the upper leg when the trunk is stable, and to flex the trunk when the leg is fixed in a position. This combination of actions helps with various movements and postural adjustments. [58] (Figure 10).

Another deep, horizontal muscle of the abdominal wall is the transversus abdominis. It begins on the inside of the lower ribs, inserts onto the linea alba and pubic crest, and arises from the iliac crest, thoracolumbar fascia, and lower ribs [59]. The transversus abdominis is primarily responsible for supporting and stabilizing the abdominal area and the lumbar spine. It acts as a corset, assisting in maintaining proper posture and providing core stability during various movements [60] (Figure 2.10).

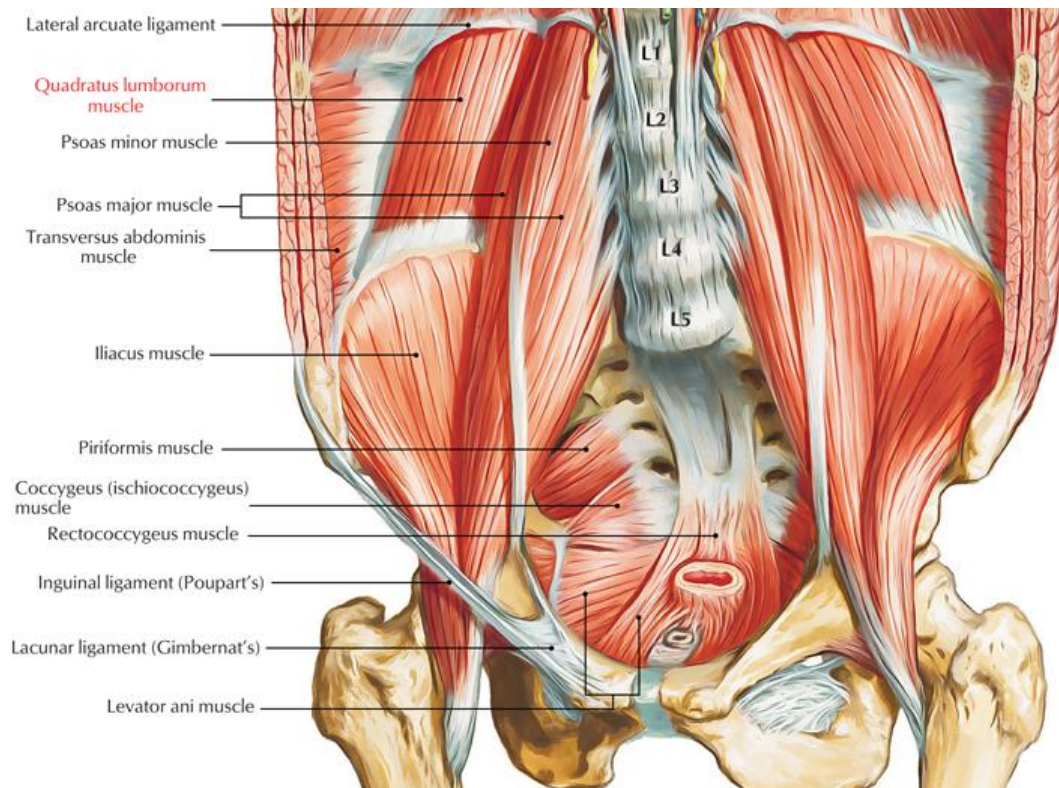


Figure 2.10. Lumbar muscles [56]

2.1.5. Spinal nerves

A spinal nerve that is created when a sensory nerve root and a motor nerve root combine to form one. Which connects the spinal cord to the body and transmits motor, sensory, and autonomic signals [61]. There are thirty-one pairs of spinal nerves, each of which is associated with a particular vertebral column segment. These comprise one coccygeal nerve, eight cervical, twelve thoracic, five lumbar, and five sacral nerves [61]. The motor nerve roots exit the spinal cord from the anterior aspect, whereas the sensory nerve roots exit from the posterior aspect. They merge to form the spinal nerves that emerge on either side of the spinal cord [61]. Two spinal nerves are formed by the union of the anterior and posterior roots, and they emerge from the vertebral canal via the intervertebral foramina. They continue as peripheral nerves once they are outside the intervertebral foramina [62] (Figure 2.11).

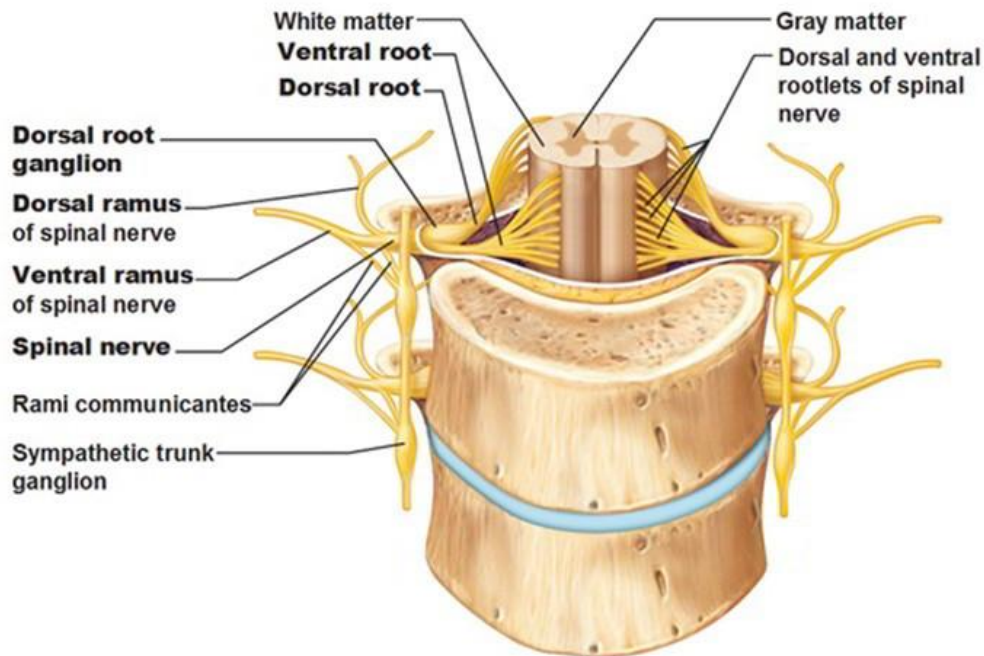


Figure 2.11. Spinal nerves [62]

2.1.6. Cauda Equina

A group of spinal nerves known as the cauda equina leave the vertebral column by passing through the lumbar cistern. The nerves that innervate the lower limbs congregate and descend through the vertebral canal before emerging at their respective levels because the spinal cord is shorter than the vertebral column (it ends at the level of L1). This collection of nerves is called the cauda equina [63] because it resembles a horse's tail (Figure 2.12).

After reaching their individual foramina and congregating at the filum terminale inside the spinal theca, these nerve roots descend at an almost vertical angle [65]. The cauda equina has roughly 10 fiber pairs at its base, comprising 1 coccygeal nerve, 5 sacral fiber pairs, and 3 to 5 lumbar fiber pairs [63]. Its main purpose is to help the pelvic organs—the bladder, rectum, and internal genital organs—and the lower limbs communicate with one another [23].

Both anterior and posterior roots make up the cauda equina roots. The lumbar and sacral plexuses, which supply motor and sensory innervation to the lower limb, pelvic, and perineal regions, are formed in part by the anterior portion of these spinal nerves. The skin,

deep back muscles, sacral, and coccygeal regions are all supplied by the posterior portion of these nerves [65].

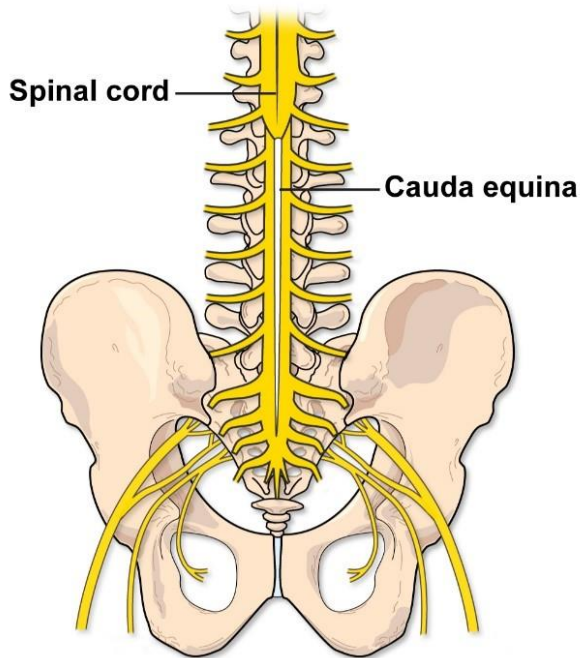


Figure 2.12. Cauda Equina [64]

2.1.7. Intervertebral discs

The intervertebral disc (IVD) is necessary to keep the spine functioning normally. It functions as the main joint in the spinal column between neighboring vertebrae and provides a fibrocartilaginous cushion. Twenty-three intervertebral discs are found in the human spine, with six in the cervical (neck), twelve in the thoracic (middle back), and five in the lumbar (lower back) regions. These discs support the spine's ability to bear weight, absorb shock, and be flexible [66]. Three main components make up the IVD: two vertebral endplates

(VEPs), the peripheral annulus fibrosus (AF), and the central nucleus pulposus (NP) [66] (Figure 2.13).

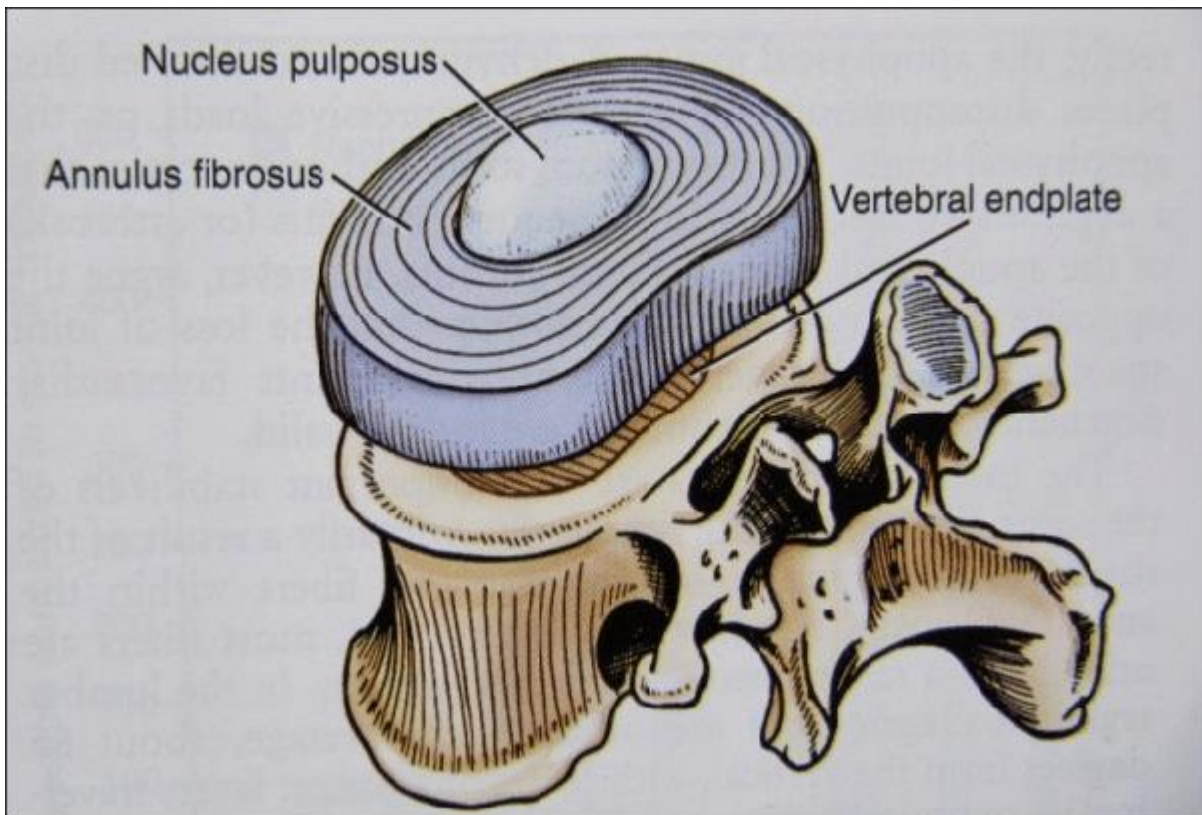


Figure 2.13. Intervertebral disc [67]

Nucleus Pulposus

It is made up of a gel structure located in the middle of the intervertebral disc, which is essential for giving the spine strength and flexibility. Its composition is roughly 66% to 86% water, with the remainder mostly made up of proteoglycans and type II collagen, which may also contain type VI, IX, and XI collagen [66]. Proteoglycans include smaller, leucine-rich proteoglycans and larger molecules that bind to hyaluronic acid, such as versican and aggrecan. Aggrecan in particular is important for the NP's ability to hold onto water. Furthermore, a small number of cells in this structure oversee maintaining the integrity of the nucleus pulposus and generating the extracellular matrix, which includes aggrecan and type II collagen [66]. (Figure 2.13).

Annulus Fibrosus

Is the outer layer of the IVD which is formed by “lamellae” or concentric inner and outer layers of collagen fibers. The outer layer contains more collagen type II. Meanwhile the inner layer is constructed of collagen type I fibers which gives it more flexibility [66] (Figure 2.13).

Vertebral endplate

Is a thin layer of cartilage located at the interface between the intervertebral disc and the adjacent vertebral body. They consist of two main regions: the superior and inferior endplate. The superior endplate is in direct contact with the lower surface of the intervertebral disc, while the inferior endplate interfaces with the upper surface of the vertebral body. These endplates are composed of hyaline cartilage and are very crucial for load distribution, nutrient diffusion, and maintaining the integrity of the disc-vertebra interface [68] (Figure 2.13).

2.2. Lower back biomechanics

2.2.1. Lumbar lordosis angle

Refers to the curvature of the lower back or lumbar spine when viewed from the sagittal plane. It is characterized by a small inward curve or concavity [69]. The exact angle of lumbar lordosis can vary among individuals and can be influenced by factors such as age, gender, and overall spinal alignment [69]. On average, the normal lumbar lordosis angle ranges between 20 to 45 degrees [70], with an average measurement of approximately 40 to 50 degrees [70]. Normal lumbar lordosis is important for maintaining the overall balance, stability, and function of the spine. Excessive or reduced lumbar lordosis can lead to misalignment, postural problems, and potential discomfort or pain [71]. To calculate the lumbar lordosis accurately, goniometer measurements can be used. However, in more clinical sitting, Cobb angle, can be used to quantify the degree of lumbar lordosis on X-ray images [72] (Figure 2.14).

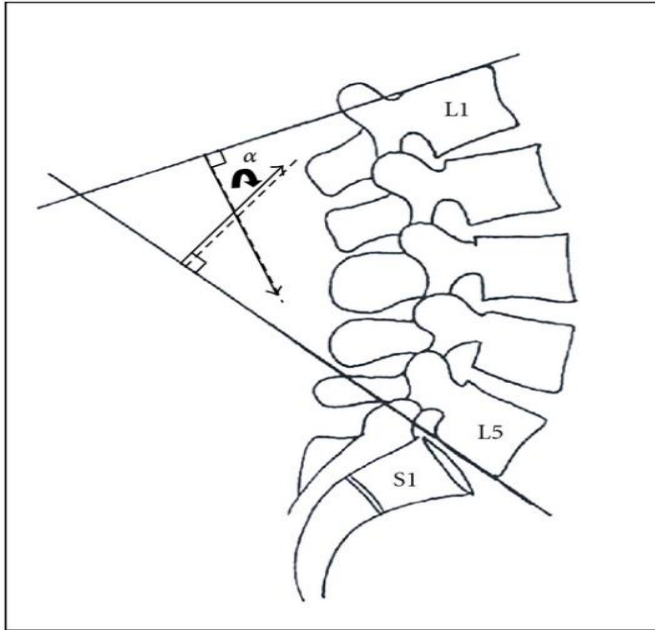


Figure 2.3. Cobb angle for lumbar lordotic curve [71]

2.2.2. Intervertebral joint

Within the vertebral column, the intervertebral joints are in charge of joining the neighboring vertebrae. An intervertebral disc joint, also called an intervertebral symphysis, and two zygapophyseal joints, also called facet joints, make up each intervertebral joint [73] (Figure 2.15).

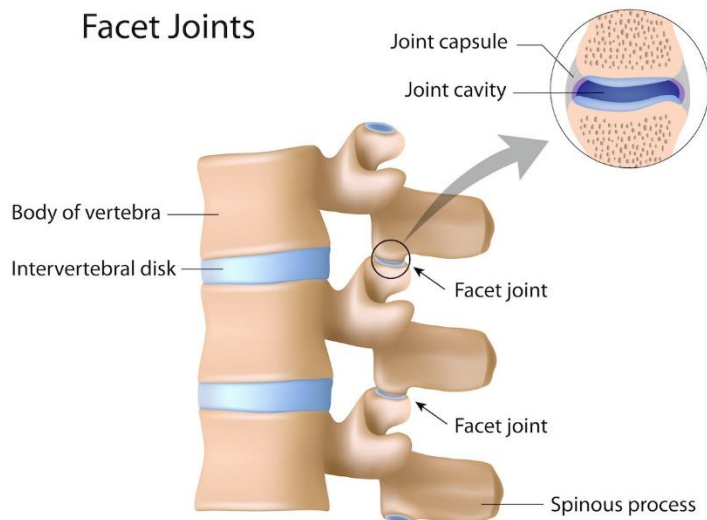


Figure 2.15. Facet joint [74]

Intervertebral disc

As mentioned before, the intervertebral disc joint, or intervertebral symphysis, is formed by the intervertebral disc based between two adjacent vertebrae (Figure 2.15). This fibrocartilaginous disc acts as a cushion and shock absorber, providing flexibility and allowing controlled movement between the vertebrae [66]. In addition, disc thickness typically exhibits a gradual increase in the caudal direction [66]. Specifically, the cervical and lumbar intervertebral discs are noticeably thicker than the vertebral bodies in relation to their size. The increased range of motion noted in these areas is consistent with this thickness differential [66]. Additionally, there is anterior thickening of the intervertebral discs in the lumbar and cervical regions. This particular anatomical characteristic aids in the development of the cervical and lumbar lordosis, two secondary curvatures in the spine [66].

Weight bearing

There are various loads applied to the intervertebral disc, including compressive, tensile, and shear stresses [75, 76]. The NP undergoes an increase in hydrostatic pressure during compressive loading, which efficiently distributes the forces towards the AF and the

endplates. This process makes it easier for applied loads to be gradually transferred to the neighboring vertebra, which gives the disc its natural ability to absorb shock [77].

Motion

Apart from its role in supporting weight, the intervertebral disc is essential for enabling different movements between vertebral bodies, such as flexion/extension, axial rotation, lateral flexion, and axial compression/distraction [78].

Migration

The nucleus pulposus may move in the opposite direction of the applied compression as a result of asymmetric compressive loading of the disc [77, 78]. As the lumbar spine flexes, the nucleus pulposus moves posteriorly. On the other hand, the nucleus is propelled anteriorly during extension. The term "dynamic disc model" is frequently used to describe this phenomenon [79].

Facet joints (Zygapophyseal joints)

The articulation between the superior and inferior articular processes of neighboring vertebrae forms these joints [34] (Figure 2.15). The facet joints, which link the vertebrae segmentally, are situated bilaterally on the posterior aspect of the spinal column [34]. Because they have articular cartilage and a synovial capsule, facet joints are categorized as synovial joints [80]. The facet joints facilitate flexion, extension, rotation, and lateral bending of the vertebral column and aid in its stability, alignment, and motion [81]. The orientation and shape of the facet joints vary throughout the spinal column, reflecting the specific requirements and functional characteristics of each region [81]. The lumbar zygapophyseal joints for example, exhibit unique characteristics in comparison to other regions of the spine

- 1- the anterior aspects of these joints are entirely replaced by ligament flava
- 2- they contain intra-articular subcapsular fat and menisci which serve to enhance joint congruity by projecting into the irregularities present on the articular surfaces [73].

Furthermore, the facet joints serve as weight-bearing structures, assisting in the distribution of loads and forces experienced by the spine [73].

2.2.4. Kinematics of the lower back

The coordinated actions of the intervertebral discs, facet joints, ligaments, and surrounding musculature, allows the lower back to exhibit a complex range of kinematic behaviors, involving flexion, extension, lateral bending, and axial rotation, among other degrees of freedom [31, 34]. The kinematics of the lower back are influenced by various factors, including individual anatomy, degenerative changes, pathologies, and muscular strength and flexibility [82, 83]. Optimal movement patterns in the lower back require a sophisticated balance between stability and mobility, with the muscles and ligaments working in concert to provide support and control, to generate accurate rotational and translational movements across the sagittal, longitudinal, and horizontal planes [34, 84]. These movements generate forces, which can be described as either pushing or pulling actions which play a role in initiating and modifying motion. When a force causes a rotational effect on a segment of the body, it is referred to as torque or moment of force [85]. Numerous forces, including compressive, tensile, shear, bending, and torsional moments, act on the sacrum and lumbar spine as a result of these spinal movements [86]. A compressive force is applied to the anterior aspect of the intervertebral disc during lumbar flexion, whereas a distractive force is applied to the posterior aspect of the disc. On the other hand, the forces acting on the disc during lumbar extension are directed in the opposite direction [34] (Figure 2.16).

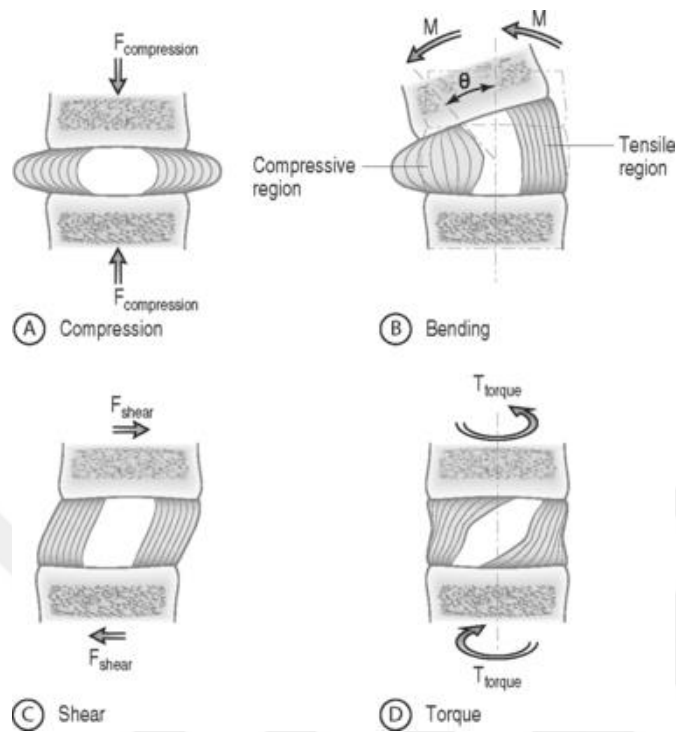


Figure 2.16. Loads on IVD [87]

Load bearing:

The lumbar spine complex is a useful system for supporting weight. Strains within the IVD are more easily produced when external loads are applied to the vertebral column, as these loads create stresses on both the relatively elastic IVD and the rigid vertebral body. The NP feels pressure even when it is at rest, which generates a preload mechanism that strengthens resistance to applied forces [83]. This causes tensile forces within the concentric annular fibers and an increase in hydrostatic pressure within the intervertebral disc, which in turn causes posterior pressure towards the vertebral endplates and bulging of the AF. This mechanism functions as a shock absorber by effectively slowing down the pressure transmission to the adjacent vertebra [34]. Because the intervertebral discs serve as fibrocartilage cushions that transfer forces between neighboring vertebrae during spinal movements, they consequently play a crucial biomechanical role. Loads applied along the spine cause the nucleus to compress, creating shear forces parallel to the IVD that cause the annulus to bulge laterally. During flexion and extension, shear forces can also be produced

when a vertebra moves anteriorly or posteriorly in relation to an adjacent vertebra. When external forces act on the spine's axis of twist, torsional stresses occur [88]. These stresses usually occur during activities that involve spinal rotation. Furthermore, by largely permitting flexion and extension motions, the zygapophysial joints resist shear forces and enhance the stability of intervertebral joints. But it's crucial to note that the lumbar disc is more vulnerable to damage than other parts of the spine because of the annular fibers' greater parallelism and thinner posteriorly than anteriorly, the nucleus' posterior location, and the holes in the cartilaginous endplates [88].

Lumbopelvic Rhythm:

Also referred to as hip-spine coordination, is the kinematic relationship that exists between the hip joints and the lumbar spine during sagittal plane movements. It characterizes the interplay and synchronization of motion between these two regions, particularly during tasks involving flexion and extension movements [89]. During activities such as trunk flexion, the lumbopelvic rhythm entails a sequential movement pattern between the lumbar spine and pelvis. First, there is flexion of the lumbar spine, and then the pelvis tilts anteriorly. The pelvis tilts anteriorly, the trunk flexes, and the erector spinae muscles contract eccentrically to control the movement against gravity. To balance the motion, the hip extensor muscles contract eccentrically and the hip flexor muscles contract concentrically at the same time. This coordinated motion facilitates smooth force transfer and supports optimal body mechanics [90]. Similarly, during trunk extension, the lumbopelvic rhythm involves a sequential movement pattern. The lumbar spine initiates the extension, followed by posterior tilting of the pelvis. The hip extensor muscles initiate the posterior rotation of the pelvis, placing it in a more favorable position for the concentric contraction of spinal extensor muscles. To control the movement, the hip flexor muscles contract eccentrically. This coordinated motion optimizes spinal stability and enables effective force generation [90]. Therefore, the lumbopelvic rhythm plays a vital role in maintaining spinal alignment, appropriate load distribution, and minimizing excessive stress on the spine. It ensures efficient movement patterns and mitigates the concentration of forces in specific regions, thus reducing the risk of injury or overloading [91]. Dysfunction or alterations in the lumbopelvic

rhythm can lead to biomechanical imbalances and increase the susceptibility to musculoskeletal issues in the lumbar and pelvic regions [31].

2.2.5. Low back proprioception

Proprioception of the lumbar region encompasses the somatosensory mechanisms responsible for perceiving and regulating the spatial orientation, motion, and positioning of the lumbar spine [92]. It entails a complex interplay between the proprioceptive receptors, neural pathways, and the central nervous system, facilitating feedback and control mechanisms specific to the lumbar region [92]. Proprioceptive input within the lumbar region originates from various sensory receptors, such as muscle spindles, joint receptors, Golgi tendon organs, and mechanoreceptors distributed throughout the ligaments, fascia, and surrounding soft tissues [93]. These receptors detect alterations in muscle length, tension, joint angles, and the external forces exerted upon the lumbar spine. The proprioceptive signals originating from these receptors are conveyed through afferent nerve fibers to the central nervous system, with the spinal cord and brain playing pivotal roles in processing and integrating this information [93]. The brain processes the proprioceptive input and generates appropriate motor responses, facilitating precise control over lumbar movement, adaptive postural adjustments, and the maintenance of spinal stability. Proprioceptive integrity within the lumbar region is essential for preserving optimal spinal alignment, coordinating complex movement patterns, and ensuring adequate stability during diverse activities [92, 93]. It serves to mitigate excessive movements, promote proper load distribution across the lumbar spine, and safeguard against injury and strain. Nevertheless, various conditions or factors, including injury, pain, muscle weakness, spinal instability, or neurological disorders, can impede the proprioceptive feedback loop within the lumbar region. Such disruptions may lead to diminished proprioceptive acuity, compromised motor control, and an elevated susceptibility to low back pain, instability, and functional limitations [94, 95].

2.3. Low back pain

Characterized by discomfort, pain, stiffness in the lower part of the back, usually above the inferior gluteal folds and between the inferior of the costal margin, with a potential for radiating to the lower limb [96]. As the fifth most common reason for doctor visits, low back pain (LBP) is a very common condition [1]. Estimates indicate that between 60 and 80 percent of people will experience LBP at some point in their lives, making it a significant condition affecting a large portion of the population [2, 97]. Chronic low back pain is particularly impactful, with studies indicating that up to 23% of adults worldwide suffer from this condition, often experiencing recurring episodes within a year [1, 3]. Lifetime prevalence rates for LBP have been reported as high as 84% in the adult population [97]. In adolescents, back pain is also a concern, with a systematic review indicating that 11.8% to 33% of adolescents experience back pain on an annual basis [97]. Furthermore, low back pain can lead to disability, affecting approximately 11-12% of the population [5]. The burden of LBP extends beyond its prevalence and includes significant socioeconomic implications. It is associated with substantial healthcare costs, work absenteeism, and reduced productivity. In the United States alone, LBP accounts for billions of dollars in medical expenses and lost productivity each year [5, 98].

Low back pain can be categorized based on the duration of the pain to three categories which reflects the duration the pain lasts.

Acute low back pain

Refers to episodes lasting from any duration up to less than six weeks [96].

Sub-acute low back pain

lasts between six and 12 weeks [96].

Chronic low back pain

Persists for 12 weeks or more [96].

2.3.1. Specific low back pain

A specific low back pain with a known cause is what the condition is classified as if one or more of the following causes have been identified [97].

Radiculopathy: This concerns pain and other symptoms that arise from the compression or irritation of a spinal nerve root; these conditions are frequently linked to spinal stenosis or disc herniation [99, 100].

Disc herniation: This condition can cause pain and nerve compression when the nucleus pulposus of an intervertebral disc pushes through the annulus fibrosus [101].

Lumbar Spinal Stenosis: This disorder is characterized by the lumbar region's spinal canal narrowing, which can result in pain and nerve compression, especially when bearing weight [102].

Spondylolisthesis: It is characterized by the anterior or posterior displacement of one vertebra relative to an adjacent vertebra, giving rise to pain and spinal instability [103].

Ankylosing spondylitis: Pain, stiffness, and progressive spinal joint fusion are the hallmarks of this chronic inflammatory disease that primarily affects the axial skeleton [104].

Osteoporosis: A skeletal condition that causes decreased bone mass and microarchitectural degradation, making people more vulnerable to back pain and vertebral fractures [105].

Lumbar spine fracture: A fracture occurring in one or more lumbar vertebrae, typically caused by trauma or underlying osteoporosis [106].

Skeletal metastases: The infiltration of cancerous cells from primary tumors into the bones, potentially resulting in low back pain if the spinal column is affected [107].

Cauda equina syndrome: A rare but critical condition characterized by compression of the cauda equina nerve roots [108].

Scheuermann's disease: A structural disorder involving abnormal kyphotic curvature of the thoracic or thoracolumbar spine, often accompanied by back pain and spinal stiffness [109].

Scoliosis: An abnormal lateral curvature of the spine, which can give rise to pain and postural abnormalities [110].

2.3.2. Non-specific low back pain

90% of patients who present with low back pain are diagnosed with non-specific low back pain, which means that specific pathological causes have not been ruled out [97].

Like specific LBP, non-specific low back pain can be divided into acute, sub-acute, and chronic categories according to how long the pain lasts.

2.3.2.1. Definition and prevalence estimations of the CNLBP

Chronic non-specific low back pain is defined as pain in the lumbar region without a specific identifiable cause or underlying pathology. This pain is usually felt between the inferior of the costal margin and above the inferior gluteal folds [96]. In the general population, the point prevalence of chronic non-specific low back pain ranged from 3.9% to 10.2%, according to a 2012 systematic review [5]. Globally, the prevalence of chronic low back pain, including both specific and non-specific causes, ranged from 2.2% to 27.2%, according to another 2018 review [98].

After specific causes, such as disc herniation, spinal stenosis, or inflammatory conditions, have been ruled out through appropriate medical evaluation and diagnostic tests, chronic non-specific low back pain is usually diagnosed. It is estimated that this non-specific category includes 85–90% of people with low back pain [2, 97].

2.3.2.2. Pathomechanics and etiology

Many innervated structures in the lumbar spine can produce symptoms of referred pain and low back pain. These structures range widely and include the dura mater, muscles, ligaments, nerve roots, zygapophyseal joints, thoracolumbar fascia, annulus fibrosis, and vertebrae. The high rate of false-positive findings on imaging studies makes it difficult to establish a clear causal relationship between pathology and low back pain, even with

advances in imaging technology. In fact, a sizable portion of people without sciatica may show signs of herniated disc material on imaging tests like myelography, magnetic resonance imaging (MRI), and computerized tomography (CT) scans [111].

Furthermore, research has shown that a significant percentage of asymptomatic individuals present with abnormal findings related to the lumbar spine, such as facet hypertrophy, disc degeneration, disc bulging or protrusion, or compression of the nerve roots [112]. On the other hand, a considerable proportion of people who suffer from low back pain might not display any discernible irregularity. Studies conducted over an extended period of time have demonstrated that low back pain can occur without altering the spine's radiographic appearance [112]. Moreover, Boos et al.'s research revealed that psychological and physical aspects of the job had a greater impact on predicting the need for medical consultation for low back pain than did disc abnormalities found by MRI [113]. As such, care needs to be taken when interpreting the relationship between radiological findings and clinical complaints. Finding a clear cause-and-effect link between an abnormality and the patient's condition is frequently difficult and may not have a major impact on patient care, even in cases where abnormalities are present [111].

However, we can attribute CNLBP to 5 potential factors that have been implicated in the development of chronic non-specific low back pain:

- 1- Musculoskeletal and Biomechanical Factors: Imbalances in the muscles, ligaments, and joints of the spine, as well as altered spinal mechanics, can contribute to chronic low back pain [5]. These factors may include muscle weakness, poor posture, spinal misalignment, traumatic injuries, and abnormal movement patterns.
- 2- Psychological and Emotional Factors: stress, anxiety, depression, emotional distress, and maladaptive coping strategies can influence and contribute to the persistence of low back pain symptoms [114].
- 3- Lifestyle and Behavioral Factors: Chronic non-specific low back pain can be more likely to develop in people who lead sedentary lifestyles, smoke, have irregular physical activity patterns, are obese, or work in physically demanding jobs [115].

- 4- Genetic and Familial Factors: A person may be more susceptible to low back pain and other chronic pain conditions if they have certain genetic predispositions. Furthermore, a possible risk factor for back pain has been identified as a family history [116].
- 5- Central Sensitization: Changes in the central nervous system's pain processing mechanisms may be the cause of chronic non-specific low back pain, which can result in increased sensitivity to pain and a decreased pain threshold [117].

2.3.2.3. Diagnosis-differential diagnosis

In order to diagnose non-specific low back pain, a number of identifiable causes must be methodically ruled out, such as scoliosis, osteoporosis, cauda equina syndrome, radiculopathy, disc herniation, lumbar spinal stenosis, spondylolisthesis, ankylosing spondylitis, and skeletal metastases [97]. Individual evaluations for each of these conditions can, however, be costly and time-consuming to complete. Because of this, medical professionals depend on identifying particular clinical indicators, also known as yellow and red flags (Table 2.1), which point to the existence of a particular or serious underlying pathology and call for additional research [118]. Red flags include age under 20 or over 55, trauma history, non-mechanical pain, history of carcinoma, HIV infection, thoracic pain, systematic symptoms, unexplained weight loss, drug abuse or steroid use, and structural spinal deformity. These flags can be used as indicators of potential underlying spinal pathology or nerve root problems. Yellow flags are psychological factors such as the expectation that passive treatment will be more beneficial than active participation, fear-avoidance behavior, low mood, social withdrawal, low job satisfaction, work-related challenges, overprotective family dynamics, limited social support, financial difficulties, and a somaticization tendency. Identifying potential nerve root indicators is also crucial (Table 2.1). Some examples include unilateral leg pain, pain that radiates to the foot or toes with or without paresthesia or numbness, and positive leg raise tests [118, 119].

Table 2.1. Red Flags for low back pain

Red flags	Nerve root problem indicator
Age less than 20 years or more than 55 years	Unilateral leg pain
History of trauma	Pain radiating to foot or toes with or without paresthesia.
Pain without mechanical nature	Straight leg raising test provokes more pain
History of carcinoma	
HIV infection	
Pain in the thoracic region	
Systematic symptoms	
Unexplained weight loss	
Drug abuse or using steroids.	
Structural spinal deformity	

Clinical guidelines advise against referring patients for imaging for non-specific low back pain unless there are clear warning signs. Red flags can help differentiate lumbar disc herniation and stenosis from non-specific low back pain. Both computed tomography (CT)

and magnetic resonance imaging (MRI) are useful in the diagnosis of these conditions. Though these particular pathologies are not very common, MRI is generally thought to be more accurate than other imaging modalities in detecting infections and malignancies [120]. Moreover, there is no solid correlation between non-specific low back pain and abnormalities found on magnetic resonance imaging (MRI) and x-ray scans. Research has indicated that the frequency of abnormalities in imaging results is comparable in those with and without low back pain. For instance, Van Tulder and Roland reported that degeneration and spondylosis were observed in 40% to 50% of individuals without low back pain [108]. These epidemiological data should be considered by radiologists when interpreting imaging results [121]. It is important to note that many individuals with low back pain do not exhibit any abnormalities on imaging scans [121].

2.4. Treatment

The goals of non-specific low back pain treatment are to reduce pain, increase functional capacity, and improve quality of life [122]. As stated in the 2017 Qaseem A, et al. clinical practice guidelines published by the American College of Physicians [123], optimizing function and enhancing quality of life are more important goals of treatment for persistent low back pain than pain relief. It's critical to help the patient understand that occasional persistent or recurrent pain is normal and does not necessarily signal a serious issue. As a general principle, interventions that involve active participation from the patient, such as physical therapy, walking, stretching, or yoga, are considered more effective in promoting long-term self-efficacy and self-management skills [123]. However, if passive interventions like chiropractic, massage, acupuncture, or relaxation techniques are used, it is recommended to introduce an active option within a week. Patients should be instructed to gradually build strength and endurance, focusing on facilitating normal movement and reducing the fear of movement [123].

In an outdated guidelines by National Institute for Health and Care Excellence (NICE) [124] for low back pain recommended the use of analgesia, pain killers and imaging. However, these guidelines have been updated in 2016 [125]. The new guidelines state that analgesia and imaging are no longer recommended unless there is a change in the

management approach. Also, the latest guidelines emphasize providing advice, promoting activity, and focusing on non-pharmacological methods of managing acute and chronic low back pain. Also, these guidelines highlight the high risks and limited benefits of pharmacological approaches [125].

Furthermore, an updated overview of clinical practice guidelines authored by Crystian et al. [126] which includes an overview of 15 different guidelines, provided a comprehensive range of recommendations. Firstly, bed rest is generally discouraged for acute LBP, as indicated by 64% of the guidelines, while promoting the continuation of normal activities and offering reassurance are commonly advised for both acute and chronic LBP (58% and 71% respectively). Nonsteroidal anti-inflammatory drugs (NSAID) are recommended by 93% of the guidelines as an effective pharmacological option, but caution is recommended by 57% of the guidelines when considering the use of paracetamol/acetaminophen. In cases where NSAIDs or other treatments prove ineffective, the short-term use of weak opioids is often suggested (87%). Referral to specialists is advised if there is suspicion of serious underlying (69%) conditions or if there is no improvement within a specified timeframe (54%). In addition, it is generally discouraged to pursue invasive treatments like injections, surgery, and radiofrequency denervation for non-specific low back pain (NSLBP). While multidisciplinary rehabilitation programs are frequently recommended for chronic LBP (90%). Psychological approaches, particularly cognitive behavioral therapy (CBT), were recommended by 91% of the guidelines to address psychosocial factors associated with LBP. Furthermore, exercise therapy was recommended by 71% of the guidelines for chronic LBP, varying in terms of the specific exercises and delivery methods. However, it is important to note that recommendations for spinal manipulation and acupuncture are not consistent across guidelines. Ultimately, the development of individualized treatment plans should take into account the unique needs and circumstances of each patient, guided by these evidence-based recommendations.

2.4.1. Surgical

In certain cases, interventions such as epidural steroid injections or nerve blocks may be considered to provide short-term pain relief. These procedures are typically reserved for individuals who have not responded to conservative treatments [123, 125].

However, guidelines generally advise against using epidural steroid injections for patients with non-specific back pain due to a lack of evidence regarding their safety and effectiveness. Corticosteroid injections into the epidural space are not approved by the Food and Drug Administration (FDA), which also warned of the possibility of rare but serious adverse events in April 2014. Serious consequences like blindness, stroke, paralysis, and even death are possible outcomes of these unfavorable events. Therefore, it is highly advised to proceed cautiously when thinking about using epidural steroid injections for non-specific back pain [127].

Radiofrequency denervation RD, also known as radiofrequency ablation or neurotomy, is a minimally invasive procedure used to provide pain relief for certain types of chronic pain, including low back pain. During the procedure, a needle or electrode is inserted near the affected nerves, and radiofrequency wave is applied to heat and block the nerve fibers that transmit pain signals which can result in temporary or long-lasting pain relief.

The UK guidelines [125] state that RD should only be considered in situations where conservative treatments have failed or in patients who have moderate to severe localized back pain that is caused by the medial branch nerve and who respond well to a diagnostic medial branch block [125].

Nevertheless, RD for chronic low back pain was the subject of a meta-analysis conducted in 2020 by Marry et al., which concluded that the evidence was of very low quality and included some degree of uncertainty [128].

2.4.2. Non-surgical

Pharmacotherapy

There have been significant changes in the recommended medications for the treatment of low back pain. When NSAIDs were ineffective or poorly tolerated, acetaminophen (paracetamol) was frequently the first-line treatment. However, new guidelines [125] advise using acetaminophen in combination with weak opioids only in these situations. It is important to use caution when prescribing NSAIDs, particularly to vulnerable

groups like the elderly or those who are more susceptible to side effects. Notably, due to scant data substantiating their efficacy, anticonvulsants, tricyclic, and serotonin reuptake inhibitor antidepressants are no longer advised. The use of opioids, too, has evolved due to the recognized risks of addiction and accidental overdose, leading to variations in guidelines. For instance, the UK guideline [125] suggests weak opioids for acute low back pain when NSAIDs are not suitable or effective, but no longer recommends opioids for chronic cases. On the other hand, the Belgian guideline [129] suggests using opioids for chronic pain, but not frequently. In contrast, the US guideline [123] states that people with chronic low back pain who have not improved with non-pharmacological and pharmaceutical treatments should only consider opioids as a last resort.

2.4.3. Physiotherapy

2.4.3.1. Conventional Physiotherapy

Self-management

Education

Patience education aims to increase the awareness of patients about the mechanical nature of their condition. Patients should be advised to maintain normal activities and provide reassurances about the severity of their condition regardless of their pain levels and durations [122]. In addition, it is crucial to educate the patients about their expectations, and reasonable goal setting [125]. It works hand in hand with other treatment options rather than being used solely [130].

Weight loss

When engaging in different activities, obesity can increase the mechanical load on the spine, putting more shear or compressive force on the lumbar spine structures. Therefore, being overweight or obese increases the risk of LBP, which can then result in CLBP, which requires medical attention, particularly for those with high abdominal fat mass. Also, obese individuals may be more susceptible to accidental injuries, further contributing to LBP. Furthermore, there may be other connections between obesity and LBP, such as systemic

chronic inflammation, hypertension, and dyslipidemia. Obesity is linked to increased cytokine production, acute-phase reactant release, and proinflammatory pathway activation. Additionally, hypertension and dyslipidemia may cause patho-mechanical factors that result in LBP. Moreover, dyslipidemia, a significant factor in obesity, contributes to atherosclerosis development, which could lead to disc cell malnutrition and predispose to disc degeneration [131].

A Korean nationwide cross-sectional study [132] investigating the relation between weight gain and CLBP, observed that individuals who gained between 3 to 6 kilos had 1.24 adjusted odds ratio higher than people who gained no additional weight, and 1.42 times higher for individuals who gained more than 6 kilos. Therefore, this study demonstrates that there is a significant association between weight gaining, obesity and CLBP.

However, in a systematic review published in 2022 [133] which included 11 studies with total of 689 patients with LBP who participated in studies concerning weight loss programs, concluded that there is an association between losing weight and the management of LBP. However, the quality of these claims are of low quality. Nevertheless, the authors regarded these results due to lack of compliance in most of the patients.

Cognitive behavioral therapy

The goal of CBT is to encourage positive behavioral and emotional changes by examining the relationship between thoughts, emotions, and behaviors. CBT for chronic LBP involves identifying and challenging negative thoughts and beliefs related to pain, developing coping strategies, and modifying negative behaviors [134]. The goal for CBT is to promote positive attitudes and behaviors towards pain, enhance self-management skills, and improve overall quality of life [122].

The main principles of CBT for chronic LBP typically include [134]:

1. Cognitive restructuring: recognizing, questioning, and substituting more realistic and upbeat ideas about pain for unhelpful or negative ones.
2. Behavioral activation: promoting participation in meaningful and pleasurable activities that pain has prevented, thus elevating mood and enhancing general functioning.

3. Pain coping mechanisms: learning and practicing various pain management techniques, such as relaxation exercises, deep breathing, pacing activities, and problem-solving strategies.
4. Education and Psychoeducation: imparting knowledge on the characteristics of chronic pain, its biopsychosocial components, and the part that behavioral and psychological aspects play in pain management and perception.
5. Goal Setting: Setting realistic goals and developing strategies to achieve them, focusing on functional improvements and increased activity levels.

The evidence for CBT is robust and strong [134, 135] therefore, the use of CBT for CNLBP was recommended in most of the studies and guidelines [126]

Orthotics

Research has been done on the topic of using orthotics as a treatment option for CNLBP. Despite the paucity of high-quality research expressly addressing orthotics for persistent, non-specific LBP, certain studies have investigated the possible advantages of these devices in connection to LBP. It's crucial to remember that every person reacts differently to orthotics.

The impact of foot orthotics on low back pain was investigated in a systematic review and meta-analysis that was published in the Journal of Orthopaedic & Sports Physical Therapy [136]. According to the review, there is some evidence that foot orthotics may help slightly lessen low back pain-related pain and disability. Nonetheless, the effects noted were negligible, and the quality of the evidence was deemed low. However, a study by Aurora et al. [137] that examined the effects of custom orthoses for patients with CNLBP and pronated feet in 101 patients shows a significant improvement in pain and disability levels. The study was published in the international journal of environmental research and public health.

Moreover, in a RCT done by Fatemeh Azadinia et. al. [138] which studied the benefits and adverse events of using lumbosacral orthosis on dynamical structure in 48 patients with CNLBP observed improvements in pain, disability, and proprioception. In addition, the impact of wearing a lumbosacral orthosis on isometric strength, endurance, and

electromyographic parameters was generally minimal. Thus, findings suggest that long-term usage of lumbosacral orthoses does not have any significant negative effects on motor function or clinical factors in individuals with CLBP.

Acupuncture

In acupuncture, tiny needles are inserted into predetermined body points as part of traditional Chinese medicine. It has been investigated as a possible CNLBP treatment option. Studies and reviews have looked into the possible advantages of acupuncture for CLBP, despite the conflicting evidence about its efficacy in treating the condition [139].

A systematic review and meta-analysis on the effectiveness of acupuncture for chronic pain conditions, including CLBP, was published in JAMA Internal Medicine [140]. According to the review, acupuncture was linked to noticeably lower pain levels than neither sham acupuncture nor no acupuncture control groups. The authors did point out that these effects might not have much of a clinical impact.

Acupuncture for non-specific LBP was the subject of a different systematic review that was published in the Cochrane Database of Systematic Reviews [141]. In comparison to fake acupuncture or no acupuncture at all, the review found that acupuncture may offer temporary pain relief and functional improvement. The evidence, however, was judged to be of low to moderate quality, and it was unclear whether acupuncture would be beneficial for chronic LBP in the long run. As a result, acupuncture was not advised for the treatment of CNLBP in the UK guidelines [125].

Electrotherapeutic modalities

Is the application of electrical stimulation for therapeutic goals. The majority of the data supporting electrotherapy's efficacy for chronic LBP is conflicting and conclusive.

An overview of Cochrane Reviews, transcutaneous electrical nerve stimulation (TENS) for CLBP, was investigated in Cochrane database systematic reviews [142]. According to the review, there is moderate-quality evidence that TENS may help people with chronic low back pain temporarily. To determine the long-term benefits of TENS for chronic

LBP, the authors pointed out that additional research is necessary, and that the clinical significance of the effects observed was modest.

In contrast, a pilot study by Joanna et al. [143] compared the effects on 127 patients with LBP of six different electrotherapy modalities: high-voltage electrical stimulation, diadynamic current, conventional TENS, acupuncture TENS, and interferential current stimulation (IF). Compared to TENS and high voltage currents, which were helpful but less effective overall, it was discovered that using electrical stimulation with interferential current results in a significant and more effective reduction of pain and enhancement of functional capability in patients with low back pain. Diadynamic currents, on the other hand, don't appear to have much of an effect. Finally, it can be said that high voltage, TENS, and interferential current are effective in treating CLBP.

However, the use of TENS, laser therapy, interferential therapy, therapeutic ultrasound, guidelines from the American College of Physicians and the American Pain Society, in conjunction with UK guidelines [144], do not advocate using these treatments with level 1a and level 1b evidence.

Manual therapy

Spinal manipulation and mobilization

Spinal manipulation is a technique that consists of high-velocity thrusts with low-amplitude applied to the targeted spinal segment to increase range of motion [145]. In contrast, spinal mobilization utilizes slow and controlled movements to reach joint physiological endpoint. The body position is highly important for these techniques to minimize possible serious complications and maximize the benefits of using spinal manipulation.

Nevertheless, there is not enough evidence in the literature to support this technique. The impact of spinal manipulative and mobilization therapies on 162 young adults with mild to moderate chronic low back pain was examined in a randomized controlled trial by James S et al. [146]. The study's findings indicated that neither spinal manipulation nor mobilization is a useful strategy for lowering pain and disability in patients with mild to moderate CNLB.

Moreover, agreeing with the previous study, a systematic review published in the journal of the royal society of medicine [147] which consistent with the conclusions of 13 of the 16 most recent systematic reviews demonstrates that the available data suggests that the usage of spinal manipulation alone is not effective method in treating any condition. In addition, a more recent meta-analysis which was published in 2019 [144] illustrates that the evidence supporting the benefits of spinal manipulation therapy (SMT) has “low to very low quality”. Regardless, NICE guidelines (125) suggest that both manipulation and mobilization should be offered as a part of a holistic treatment plan.

Massage therapy

In a systematic review conducted by Cochrane reviews [148], which analyzed 25 trials involving a total of 3,096 participants, the effectiveness of therapeutic massage for LBP was evaluated. The review concluded that despite some positive outcomes observed in pain reduction for individuals with any stage of LBP in the short-term following massage therapy, the long-term benefits remain uncertain. This suggests that the efficacy of massage as a viable treatment for LBP is of low quality. Moreover, the review found that participants with sub-acute and chronic LBP experienced functional improvements when compared to inactive controls. However, these improvements were also limited to the short-term follow-up period, indicating that the long-term effects of massage on functional outcomes are unclear. Nevertheless, the adverse effects resulting from massage were minimal and of minor significance, indicating that it is generally a safe treatment option. However, it is important to note that while massage may offer temporary relief and modest functional gains for individuals with LBP, its overall effectiveness as a long-term treatment remains uncertain, as supported by the systematic review's findings. The findings of this meta-analysis are consistent with the results of a previous meta-analysis which was published in 2013 in International Journal of General Medicine [149] which also suggest that the quality of evidence supporting the benefits of massage therapy are of a low quality. Nevertheless, NICE guidelines (125) suggest that therapeutic massage should be offered as a part of a holistic treatment plan.

Myofascial releasing

Myofascial release (MFR) is a therapeutic technique used to treat muscular tension and pain by targeting trigger points in the fascia, which is a connective tissue that surrounds and supports muscles, bones, and organs in the body. The goal of myofascial release is to release restrictions or adhesions within the fascia which are known as trigger points. Releasing trigger points improves range of motion, decreases pain, and enhanced overall function [150]. This can be done using various techniques, including direct pressure, stretching, and manipulation of the fascia. The pressure applied during myofascial release aims to elongate and reorganize the fascia, reducing restrictions and improving tissue mobility [150].

In a study conducted Arguisuelas et. al. to study the effects of MFR for patients with CNLBP concluded that using MFR helps in reducing pain and disability [151]. Also, in a meta-analysis [152] published in the Complementary Therapies in Medicine journal, which included 8 RCTs with overall 386 participants with LBP indicates that MFR when combined with physical therapy and exercise therapy can enhance the effectiveness in reduction in back disability. However, it did not show a significant impact on reducing pain intensity, improving quality of life, or enhancing the range of motion in the lumbar region. In another meta-analysis [153] which also included 8 RCTs but with 375 patients with CLBP which reviewed and quantified the efficacy of MFR concluded that pain and physical function were significantly improved. However. no significant improvements in balance, pressure-threshold, mobility, mental health, and overall quality of life. Moreover, it is worth mentioning that using MFR was found to be an effective method to correct the posture in 30 patients with CNLBP in a study conducted by Hassan Tamartash and Farid Bahrpeyma [154].

Lumbar Traction

Traction is a therapeutic method which consists of applying stretch force over the joints to distract and increase the articular space by pulling the joint or joints apart. Lumbar traction is applying these stretch forces over the lumbar area to decrease pressure over the lumbar vertebrae [155, 143]

The evidence of lumbar traction as an effective intervention for LBP is inconclusive and conflicted between old and new studies. Old study [156] which was published in 1997

and a newer one which was published in 2003 [157] claimed that using lumbar traction for patients with LBP is not effective in reducing pain nor increasing function. However, in a new crossover, repeated measures, randomized controlled trial published in 2021 [158] which includes 95 participants demonstrate that the improvement in pain levels and functionality statuses were illustrated immediately after applying lumbar traction. Nevertheless, the study's two-week follow-up period is extremely brief. Thus, this trial did not include long-term effects. Furthermore, the use of lumbar traction for patients with CNLBP is not advised by NICE [125], Kaiser guidelines [122], American College of Physicians and the American Pain Society guidelines [140], or Belgian guidelines [129].

Taping

Applying an elastic tape to the skin at different stretch levels is known as therapeutic elastic taping, or kinesio taping (KT), and it is used to improve joint motion by realigning weak muscles and improving muscle alignment. Furthermore, this stretch produces a mechanical stimulus that triggers the Central Nervous System (CNS) afferent pathway [159]. Furthermore, it changes the concentration and density of tissue in the dermis and epidermis when applied with a low degree of stretch. This results in mechano-transduction, which is the process by which the mechanical stimulus is transformed into electrical impulses that can stimulate cell movement and enhance joint proprioception [159]. The pressure and stretch exerted by KT on the skin have the potential to stimulate mechanoreceptors, interacting with the CNS and modulating pain responses [159]. Additionally, by allowing the fascia to move freely as a result of the skin's movement in relation to the target tissue, the application of this tape influences the tension elements in tissues, promoting homeostasis [159]. Additionally, Kinesio Tape creates a lifting effect on the skin that causes dynamic pressure variations that open microvalves, increasing the space beneath the skin and promoting lymphatic fluid circulation and blood flow. Tissue swelling and inflammation are reduced as a result [156]. It is also hypothesized that the tape's lifting of the skin creates channels for lymph drainage by separating the filaments that hold the skin to the endothelial cells of the lymphatic and capillary beds. This combination of effects aims to enhance overall joint stability and proprioceptive awareness during movement. In summary, Kinesio Tape offers theoretical benefits that extend beyond its influence on the CNS, skin, fascia, and lymphatic and

circulatory systems. These potential advantages include correcting muscle alignment, facilitating joint motion through tape recoil, lifting the skin to increase space and improve blood flow and lymphatic circulation, reducing pressure on nociceptors, and stimulating mechanoreceptors to enhance joint proprioception.

Literature is rich with information and RCTs studying the effects of KT in general and for patients suffering from CNLBP. However, these results are conflicted, with the majority of studies suggesting that there are no benefits for using KT to reduce pain levels or disability status for patients with CNLBP not in the short term [160], medium term when used for four weeks [161]. The results of these studies are also supported by a meta-analysis published in the Spine journal [162] which indicates that the quality of evidence favoring KT for individuals with CNLBP are of low-quality nature and should be disregarded and not used in clinical practice.

Nevertheless, it is worth mentioning that short terms effects are likely and were proven effective in some studies. In a RCT [163] done on 180 women with LBP, it concluded that using KT without tension reduced pain in participants after 3 days of its application. In addition, when tension was applied the authors noticed improvements in disability levels between 3 to 10 days of applying the tensioned tape. Moreover, in another RCT published by Aslihan Uzunkulaoğlu et. al. [164] which included 60 patients, to assess the effectiveness of KT for suffering from CNLBP. The results of this study suggest that the short-term effect of using KT were significant when it comes to pain range of motion (ROM), and disability. In addition, the effects over ROM and disability continued and were observed at the 6 months follow-up, which also suggests that the benefit of KT is not only for the short term but is also sustained.

Exercise therapy

Yoga

According to the American osteopathic association [165] regular practice of yoga can help individuals achieve greater flexibility, strengthen, and tone their muscles, and experience improved breathing patterns, leading to increased energy and vitality. It also aids in maintaining a balanced metabolism, which can contribute to weight reduction.

Furthermore, yoga has positive effects on cardiovascular health, helping to improve the functioning of the heart and circulatory system. Additionally, practicing yoga can help reduce the risk of injuries by promoting body awareness, proper alignment, and strength.

However, for chronic non-specific low back pain in adults, the study by L. Susan Wieland et al. [166] compared yoga to control yoga, no specific treatment, minimal intervention, or another active treatment. According to the research, yoga, as opposed to doing no exercise, produces marginal and clinically insignificant improvements in back-related function and pain. After three months, there probably isn't much of a difference in back function between yoga and other back exercises, but there are still questions about possible variations in pain and quality of life. Furthermore, when compared to not exercising at all, yoga is linked to a higher incidence of adverse events. But the chance of negative outcomes might be comparable to that of other training methods.

Furthermore, the principal goal of a meta-analysis conducted by Feilong Zhu et al. [167] is to assess the impact of yoga as an intervention on pain levels, disability, and quality of life in people with persistent low back pain. concluded that yoga has a very low to moderate efficacy rate for people with persistent low back pain. Nevertheless, no appreciable variations were found when comparing the impact of yoga on pain and disability with that of other exercise modalities or physical therapy.

Tai chi

According to Harvard medical school [168], Tai chi is a pattern of circular non forced motions without pauses. Tai chi can be described as "meditation in motion," or "meditation in motion." It differs from other exercise programs but not force on muscles and joints, rather focusing on the relaxation of muscles, joints, tendons, and connective tissues. Also, it can be easily adapted to suit anyone in any physical conditions. In addition, Tai chi's benefits encompass various physical aspects: it enhances both lower-body and upper-body strength, including the core muscles of the back and abdomen, improves flexibility in the upper and lower extremities, and effectively enhances balance and proprioception, thereby reducing the risk of falls. Although it provides some cardiovascular benefits depending on the intensity of movements. Overall, tai chi offers a comprehensive approach to physical well-being, making it a valuable addition to any fitness routine [168].

Liye Zou [169] conducted a thorough review that compared the effects of mindful exercises to active and/or non-active controls. The review's findings indicated that Tai chi was superior to other forms of mindful exercises in terms of pain management and was an effective way to reduce disability.

Pilates

Pilates drew inspiration from a variety of disciplines, including ballet, Zen meditation, yoga, martial arts, and ancient Greek and Roman exercises [170]. The transversus abdominis, diaphragm, abdominal oblique muscles, multifidus, and pelvic floor muscles are among the core muscles that are activated during exercises in the Pilates method. This helps to stabilize the lumbopelvic complex. Concentration, or paying close attention to details when performing Pilates exercises properly. Control: Exercises require focused attention to detail as well as exact control over posture and movement. Accuracy to guarantee the standard of exercise methodology. To engage the deep trunk muscles during exercise, breathing is synchronized with movement. The fluidity and seamless transition between exercises is referred to as flow [170].

In a review published in the Postgraduate Medical Journal [170] suggest that Pilates-based exercises can benefit patients with CNLBP as a standalone treatment. Positive effects, including pain reduction and improved function, have been observed in the short term. However, variations in study methodologies and small sample sizes limit conclusive findings. Supervised Pilates sessions led by qualified instructors, lasting approximately 60 minutes, two to three times per week, are recommended, with exercises tailored to individuals. The superiority of mat-based or equipment-based Pilates remains uncertain due to conflicting results.

To evaluate the impact of Pilates on patients with CLBP, Hui et al. [171] carried out a systematic review. The review contained eight articles that were randomized controlled trials. When compared to patients with CLBP who received standard care, patients who underwent Pilates exercises showed statistically significant improvements in both pain relief and functional ability. Nevertheless, other types of exercise demonstrated comparable effects when waist or torso movements were incorporated.

Aerobic exercises

The use of aerobic exercises for patients with chronic non-specific low back pain (CNLBP) has been a topic of discussion among different guidelines. The UK guidelines [125] recommend the incorporation of aerobic exercises as part of the treatment approach for CNLBP. Aerobic exercises, such as walking, swimming, or cycling, are known to improve cardiovascular fitness, increase overall endurance, and promote general well-being.

However, the Belgian guidelines [129] take a slightly different stance on the role of aerobic exercises in the management of CNLBP. They suggest that there is limited evidence supporting the direct effect of aerobic exercises when performed alone in alleviating CNLBP symptoms. Instead, they propose that aerobic exercises should be integrated into more comprehensive and holistic exercise programs for better outcomes.

Core stabilization exercise

Enhancing spinal stability and regaining appropriate muscle function are the main objectives of core stability exercises. People can strive to create a more stable and well-supported spine by concentrating on core stability, which will ultimately lower the risk of further damage and improve overall function. The significance of core stability has gained attention in recent years due to various studies showing specific problems in people with chronic low back pain (CLBP). These problems include loss of normal transversus abdominis activation during activities such as walking and limb movements, as well as reduced or delayed activation of the lumbar multifidi and transversus abdominis muscles. When these muscles are dysfunctional, the lumbar spine may become less supported and the lumbar spine's joints and ligaments may be subjected to increased stress and strain [172].

Muhammed et al. [149] investigated the efficacy of core stabilization exercises in comparison to routine exercise therapy for the management of pain in 120 subjects with CNLBP. The trial was a single blinded randomized control trial. It was discovered that core stabilization exercises were superior to regular physical therapy exercises in terms of their ability to lower pain levels.

Furthermore, 49 papers on the efficiency of core stability exercises in lowering pain and enhancing disability in people with non-specific chronic low back pain were included in

a review that was published in 2021 [173]. shows that patients with CNLBP can benefit greatly from core stability exercises in terms of pain management, functional disability improvement, quality of life enhancement, and core muscle activation and strengthening. According to the evidence, core stability exercises are more beneficial for CNLBP than rest or minimal intervention alone, and their combination with other forms of exercise shows even greater benefit. This highlights the critical role that patient compliance plays in the process.

Motor control exercises

In order to restore the coordinated and efficient use of the muscles that support and control the spine, motor control exercise is a very well-liked and beneficial type of physical activity. Patients are first instructed on how to use their muscles correctly for basic tasks before advancing to increasingly difficult and functional exercises that use their trunk and limb muscles. These exercises are designed to enhance posture, improve the quality of movements, and reduce pain related to spinal conditions [174].

In an investigation into the effectiveness of motor control exercises (MCE) for patients with CNLBP, a systematic review comprising 29 trials was published in the Cochrane library [174]. suggests that limited to moderate quality findings, which can range from low to high quality, support the impact of MCE on CLBP and show that MCE is not clinically superior to other exercises. Furthermore, a meta-analysis with studies included was published by Zhang C et al. [175] and supported these findings. Nonetheless, there is low to moderate quality evidence indicating that MCE is effective in the short, intermediate, and long term at reducing pain when compared to minimal intervention [174].

Moreover, a second systematic review with 18 trials was carried out [152]. which, when compared to a control group that did not receive additional exercise, revealed moderate-to-high quality evidence supporting the beneficial effect of motor control stabilization exercise on current pain, chronic pain intensity, and self-reported disability among people with low back pain.

Back School programs

Educational and training programs to reduce pain [176], reduce kinesiophobia, increase functional recovery and tissue repair, or even to prevent low back pain from developing. Typically consists of four 45-minute sessions spread over a two-week period which focuses on three main parts [176]. First the patients are educated about the anatomy and function of the spine, spinal biomechanics, physiopathology of frequent back disorders. Then the individuals are trained on biomechanical principles and posture in various positions. Lastly, active protection of the spine by engaging in exercises that actively protect the spine. This can include stretching exercises for lower limb muscles and erector spinae muscles, kinaesthetic training involving controlled pelvic movements, and core strengthening exercises with a stabilizing function.

However, in a review by the Cochrane library [177] which included 30 trials found that the evidence of the effectiveness of Back School for CLBP pain is limited and generally low-quality evidence. Although the evidence quality was mostly very low, the results indicated either no difference or a minor favorable effect associated with Back School. In addition, supporting these statements, another meta-analysis done on 31 studies [176]. It was found that the evidence behind Back School programs is insufficient and has a low quality.

McKenzie therapy

The McKenzie method, also known as mechanical diagnosis and therapy (MDT), is a diagnostic and treatment system used for musculoskeletal disorders affecting the spine and extremities. This method differs from other methods by focusing on patient empowerment and self-treatment, and instead of categorizing patient complaints solely based on anatomical factors, MDT groups them according to their clinical presentation [178]. The MDT process involves four steps: assessment, classification, treatment, and prevention. During the assessment, the clinician gathers information about symptoms and identifies activities that worsen or alleviate them. Movement assessments are conducted to evaluate movement limitations and the response of symptoms to specific movements. Based on the assessment, the patient's symptomatic response leads to a classification, such as derangement syndrome or dysfunction syndrome, which guides the choice of exercises. In the treatment phase, the goal is to find movements that reduce or eliminate symptoms and maintain this improvement over several days. Recovery of function exercises are then performed to assess if previously

painful movements can now be done without pain. Lastly, in the prevention step, the patient is educated and encouraged to engage in regular exercise and self-care, with exercise recommendations tailored to the direction that reduces symptoms. Consistently following a specific direction of movements or postures can sequentially alleviate distal referred symptoms, ultimately reducing or eliminating spinal pain [179, 180].

Evidence shows that MDT is an effective treatment for the reduction of pain, disability and increase function in the long term [181]. However, in a systematic review [182] compared MDT to traditional physical therapy interventions, it was concluded that MDT is an effective treatment for CLPB but not superior to other physical therapy interventions.

Strengthening and stretching exercises

Exercises that build strength are crucial for treating CNLPB. Computed tomography (CT) and magnetic resonance imaging (MRI) have shown evidence of significant degenerative changes in the lumbar extensor muscles, especially the multifidus, in people with back pain [183]. In a research by Dickx et al. [184], injections of a hypertonic solution caused pain in healthy subjects and decreased multifidus and erector spinae muscle activity. Patients with CLBP showed reduced muscle mass in their lumbar extensors, according to Parkkola et al. [185]. In a study involving people with a history of chronic back pain, Rissanen [186] discovered that intense back extensor strengthening exercises led to an increase in type 2 multifidus fiber diameter and a significant increase in strength, indicating the multifidus' adaptability to strengthening exercises. These results confirm the benefits of intense resistance training for the lumbar extensor muscles in people with CLBP, as noted by Mooney et al. [187]. These studies also showed that as strength and range of motion increased, the lumbar extensors' myoelectric activity changed.

Furthermore, it is indisputable that stretching exercises (ST), particularly when paired with strengthening exercises, are beneficial for patients with CNLBP. 25 RCTs on exercise interventions for CLBP were examined in a systematic review and meta-analysis that was published in the Journal of Orthopaedic & Sports Physical Therapy [188]. The review discovered that patients with chronic low back pain could effectively reduce pain and improve their function by engaging in exercise therapy, which included strengthening and stretching exercises. A 2011 study comparing the efficaciousness of yoga, stretching

exercises, and self-care booklets for chronic low back pain was published in the *Annals of Internal Medicine* [189]. According to the study, patients with chronic low back pain were able to improve their function and reduce their symptoms more effectively with yoga and stretching exercises than with self-care booklets.

In 2016, a different systematic review and meta-analysis [190] evaluated the efficacy of exercise therapy for chronic low back pain. Exercise therapy, especially strengthening exercises, was found to be effective in reducing pain and improving function in patients with chronic low back pain, according to a review that included 39 RCTs.

2.4.3.2. Tele-rehabilitation in Physiotherapy

Overview

Technology has brought about a revolution in various aspects of the healthcare system. Specifically, advancements in the provision of cutting-edge treatments as well as the way specific interventions are delivered [191]. In response to these shifts in healthcare and demographics, the integration of technology into rehabilitation services has become not just a convenience but a necessity [191].

Leveraging technology to deliver rehabilitation services offers numerous advantages for both healthcare providers and their patients. It empowers patients, granting them a sense of personal autonomy and control over their condition management, transforming them into active partners in their care rather than passive participants [191]. For healthcare providers, tele-rehabilitation allows for a more efficient allocation of resources. It reduces the strain on physical facilities and staff by providing services remotely, making it possible to reach more patients without the constraints of traditional brick-and-mortar clinics. This not only maximizes the use of available personnel but also enhances their job satisfaction as they can interact with patients in a flexible and supportive manner [191].

A significant component of the change is telerehabilitation, which is the use of information and communication technologies (ICT) to deliver rehabilitation services to people in remote locations, like their homes or other settings [191]. For people with

disabilities, these services include training, consultations, educational materials, remote progress tracking, therapeutic interventions, and networking opportunities [192]. Moreover, tele-rehabilitation contributes to reducing healthcare costs in several ways. It minimizes the need for expensive infrastructure, such as specialized rehabilitation centers, and slashes travel-related expenses for patients and their families. The overall cost savings are significant, both for the healthcare system and the patients themselves [192].

Moreover, it guarantees access to care for people living in isolated locations or experiencing mobility problems as a result of physical limitations, transportation problems, or socioeconomic circumstances [192]. It also lessens the time and financial strain that comes with travel for medical professionals as well as patients [193]. Studies have revealed that the rehabilitation requirements of people with chronic illnesses like stroke, traumatic brain injury (TBI), and other neurological disorders are frequently not sufficiently met in their communities [192]. In addition, as the elderly population continues to grow, the demand for healthcare services, including rehabilitation, will intensify. Technology, particularly tele-rehabilitation, is poised to be a cornerstone in addressing these growing healthcare needs efficiently and sustainably [193].

The growing field of telerehabilitation promotes better patient continuity of care. It removes the obstacle of physical distance between clinician and patient, allowing clinicians to provide remote patient care outside of traditional medical settings [191].

Delivery methods

1. Telephone communication: In the early projects, self-assessment tools and follow-up support were provided by clinicians over the phone [194].
2. Pre-recorded video materials: pre-recorded video materials for clients and interactive use in physiotherapy were introduced in the 1980s [195].
3. Video conferencing: In the 1990s, it became clear how useful video conferencing could be in the healthcare and telerehabilitation fields. In particular, physiotherapy emerged as a crucial element of telerehabilitation through the use of video conferencing [196]. Russell et al. (2011) conducted a randomized control trial (RCT) to determine the efficacy of an internet-based telerehabilitation system for outpatient

rehabilitation after total knee replacement (TKR) versus traditional physiotherapy. According to the study, both rehabilitation approaches produced results that were comparable, and patients' satisfaction with telerehabilitation treatment was high [197]. Moreover, videoconferencing technology allows for both verbal and visual communication between participants during consultations, diagnostic evaluations, and the administration of treatment interventions [198].

4. Sensors and remote monitoring technologies: These advancements let professionals monitor patient adherence to particular exercise regimens and let patients keep an eye on their at-home workouts [199].
5. Virtual reality: this technology enables real-time user interaction with computer-generated environments. Real-world scenes are first used to create virtual environments that mimic real-world situations in virtual reality [200]. Virtual environments are useful for surgical procedures, physical rehabilitation, training, and education for healthcare professionals.
6. Smartphone Apps: Patients, medical students, healthcare providers, and the general public can all download a variety of mobile apps [201].

3. MATERIAL AND METHOD

3.1. Subjects

72 patients with chronic non-specific low back pain CNLBP (41M, 31F) were included in this study through Telegram and WhatsApp groups and individual advertisement campaign, in addition to 40 highly active Facebook advertisement groups between February 2023 and June 2023.

Patients who met the inclusion criteria were randomly (by internet based random number generator) divided into three groups as Real-Time Synchronized Telerehabilitation Program (Group 1, $n=24$, 43.21 ± 12.53 years), Pre-Recording Non-Synchronized Telerehabilitation Program (Group2, $n=24$, 38.79 ± 10.39 years), and Home based non-supervised exercise Program (Group3, $n=24$, 41.79 ± 10.009 years).

Sample Size Calculation:

An adequate sample size was calculated using G*power 3.1.9.7. The statistical test fixed effects one-way ANOVA, the probability for alpha error (α) at 0.05, large effect size $f = 0.4$, power = 0.8, and three groups. A total of 66 subjects was calculated as the minimum required sample size. In addition, based on previous studies a dropout rate was set at 10%. Hence, the total sample size was increased to 72. Therefore, each group will have 24 subjects ($n=24$).

3.1.1. Inclusion criteria

- Persisting low back pain for the past 3 months.
- VAS score of at least 4.
- Age between 18 and 65.
- Ability to perform exercises.
- Internet access.

3.1.2. Exclusion criteria

- Pregnancy.
- History of spinal surgery.

- History of spinal injury.
- Misalignment or specific condition in the lumbar region.
- Inflammatory joint diseases.
- Any neurological symptoms.
- Diagnosed osteoporosis.
- Spondylosis.
- Radiculopathy in the lumbar region.
- Having a current inflammation in the trunk, lumbar or pelvic region.
- Receiving physical therapy or other conventional therapy for LBP in the past 6 months.
- Regular practice for Pilates or other specific exercise programs in the last 6 months

The study Protocol was approved by Marmara University Ethical Committee at the date of 25.05.2023 and issue number 70 (Appendix 1). Participants involved in this study on voluntary basis. The aim and the plan explained and informed written consent (electronic based) was obtained from each patient (Appendix 2).

3.1.3. Flow Chart: Study Prosses

A total of 72 patients were admitted to this study through an online advertisement campaign. Subjects having non-specific low-back pain lasting longer than 3 months were included in the study according to the inclusion and exclusion criteria. Randomization was conducted on all cases which are divided into three groups as Real-Time Synchronized Telerehabilitation Program (Group 1), Pre-Recording Non-Synchronized Telerehabilitation Program (Group2), and Home Based Non-Supervised Exercise Program (Group3) by website base random number generator (Figure 3.1)

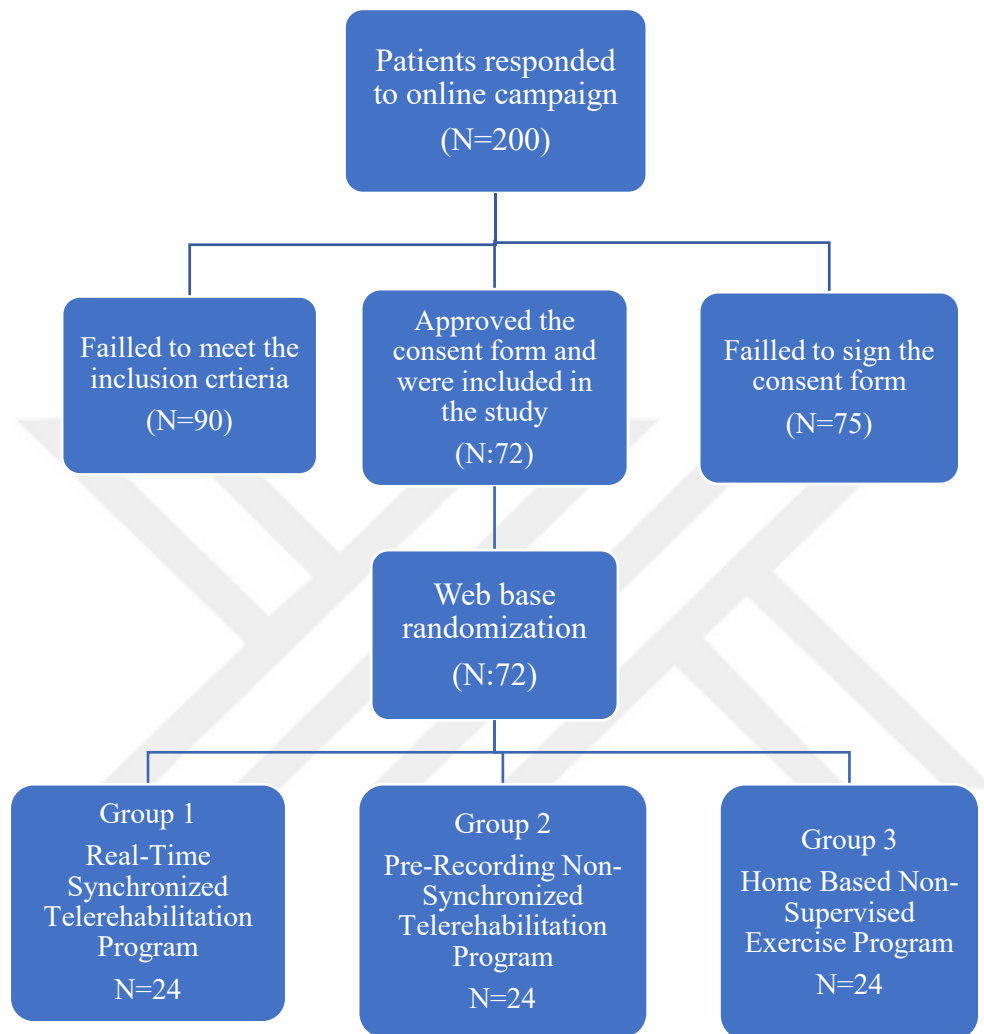


Figure 3.1. Flow Chart of Study

3.1.4. Study protocol

At the beginning of the study (week 0) all patients received educational seminar through google meet. A recording of the session was sent to subjects who could not participate in the session. Real-Time Synchronized Telerehabilitation Program (Group 1) received 2 sessions per week through ZOOM. Pre-Recording Non-Synchronized Telerehabilitation Program (Group2) received 3 videos demonstrating the exercises at week 0, week 5, and week 9. Home Based Non-Supervised Exercise Program (Group3) received a

booklet that includes all the stages at week 0. The total duration of the rehabilitation program was 12 weeks for all groups (Figure 3.2).

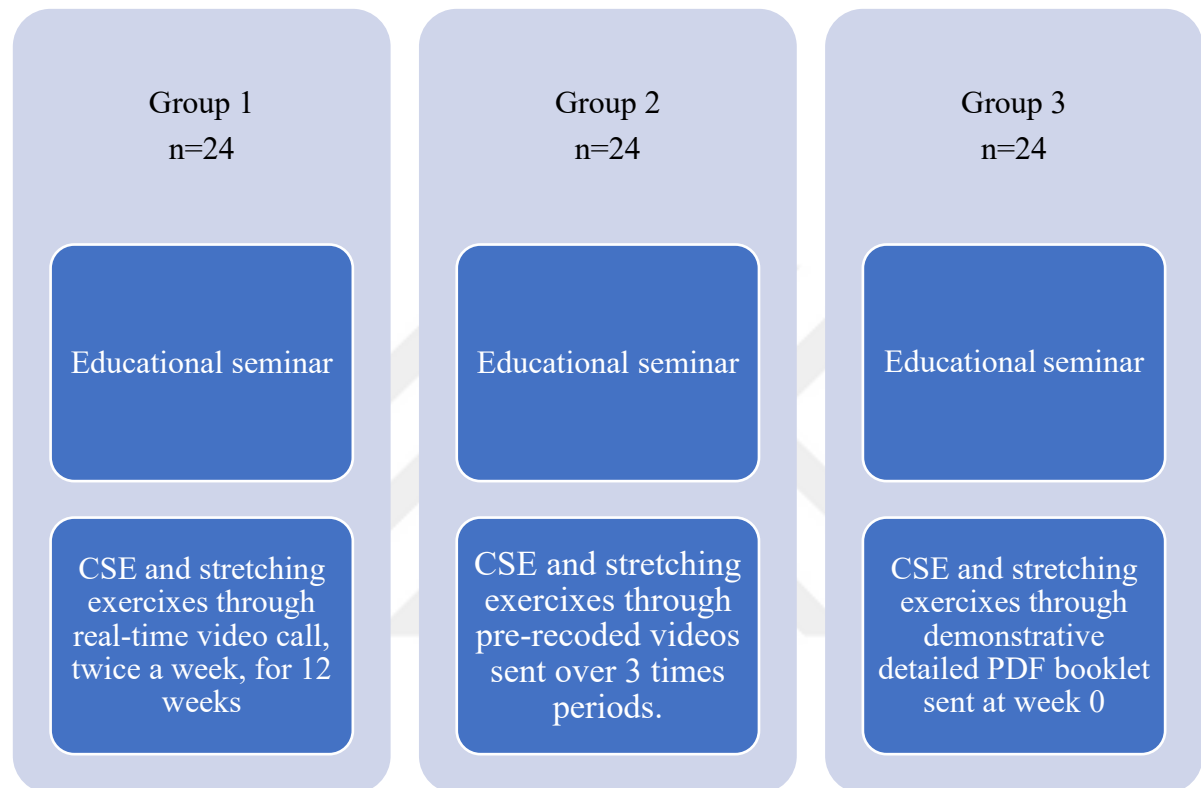


Figure 3.2. Study Protocol

3.2. Evaluation

Patients were evaluated two times; preintervention (week 0), and post interventions (week 12). All measurements were recorded at week 0 and the end of week 12

T0: preintervention

T1: 12th week

3.2.1. Structured questionnaire

Questionnaire prepared by research to accumulate information regarding age, weight, gender, BMI, dominant side, existing chronic diseases, family history, traumatic history, and whether the participant engaged in any sports or structured exercise programs before

(Appendix 3). Patients typed their answers as “short answers” on the prepared preintervention google forms.

3.2.2. Pain assessment (VAS)

Is a visual scale with various types to measure the intensity of the pain where 0 is considered no pain and 10 is unbearable pain. VAS can be just a 100mm horizontal line where patients can put a mark anywhere on the line, or graphics indicating the severity of pain [202]. Also, it can be numerical line from 0 to 10 which was used in this research.

Patients were asked to rate their low back pain, 0 indicating the absence of pain, 1 to 3 indicating moderate pain levels, 4 to 6 indicating moderate to severe pain levels, 7 to 9 indicating severe pain levels, and 10 indicating worst pain possible, on a linear scale from 0 to 10 on the prepared assessment google forms (Appendix 4). VAS is a reliable method to measure pain and considered as a standard assessment tool for measuring pain levels [202].

3.2.3. Disability assessment

Two measurement tools were used to assess the level of disability.

Roland Morris Disability Questionnaire (RMDQ)

A sensitive and reliable evaluation tool, to measure disability in patients with chronic non-specific low back pain. It contains a 24-item scale with a total score ranging from 0 (no disability) to 24 (high disability) [203]. The questionnaire was prepared in the questionnaire was delivered electronically as checkboxes question on the prepared assessment google forms (Appendix 5).

Patients were asked to only choose the sentences that describes how they feel today and skip the sentences that does not.

Oswestry Disability Index (ODI)

Is a gold standard, valid questionnaire, which assesses disability in ten distinct parts: pain intensity, patient personal care, lifting, walking, sitting, standing, sleeping, social life, sex life and travelling. Each statement is scored from 0 to 5 with higher scores demonstrating more disability [204]. The questionnaire was prepared and delivered electronically as ten multiple choice questions on the prepared assessment google forms (Appendix 6).

Patients were asked to choose the part that most closely describes how they feel today.

3.2.4. Kinesiophobia assessment

Tampa Scale for Kinesiophobia (TSK) was used to assess fear of movement. Which is a 17-item measure used to gauge patients with CNLBP's fear of injury and movement. There are four possible scores for each item: one point for "total disagree" and four points for "total agree." The scale's overall score falls between 17 and 68, with 17 denoting no kinesiophobia, 68 denoting severe kinesiophobia, and a score of ± 37 denoting the presence of kinesiophobia [205]. The survey was created and distributed digitally as a set of 17 multiple-choice questions on Google Forms for the prepared assessment (Appendix 7). Patients were asked to choose the truest statement, based on the way they feel how much each sentence represents them.

3.2.5. Quality of life assessment

The SF-12 Health Questionnaire. Which is a survey that gauges life quality by evaluating how health affects day-to-day activities. It makes use of the same eight domains as the SF-36: body pain, general mental health (psychological distress and well-being), limitations in usual role activities due to emotional problems, vitality (energy and fatigue), limitations in physical activities due to health problems, limitations in social activities due to physical or emotional problems, limitations in usual role activities due to physical health problems [206]. The survey was created and sent electronically using 12 multiple-choice questions on Google Forms for the prepared assessment (Appendix 8). Patients were asked to mark one box that best describes their answers.

3.3. Management modalities

3.3.1. Education

An educational seminar was held at the beginning of the program. The content of the session was as follow:

- General anatomy, physiology, and biomechanics of the back, with emphasis on the lumbar region.
- General causes of low back pain.
- Definition and possible causes of CNLBP.
- Mechanism of pain.
- Information about pain management according to cognitive behavioral therapy (CBT).
- The importance of good posture.
- Examples of good postures in standing, sitting, walking, and lifting.
- At the end of the presentation, time for questions was provided.

The session was held using google meet (Figure 3.4). The attendance for the seminar was voluntary. Patients were informed about the date and time of the session a week before and were reminded again with the link for the session an hour before the beginning of the session. In addition, patients were informed that a recording of the presentation will be sent for those who could not attend the session. The duration of the session was 30 minutes for presentation and an additional 30 minutes for questions.

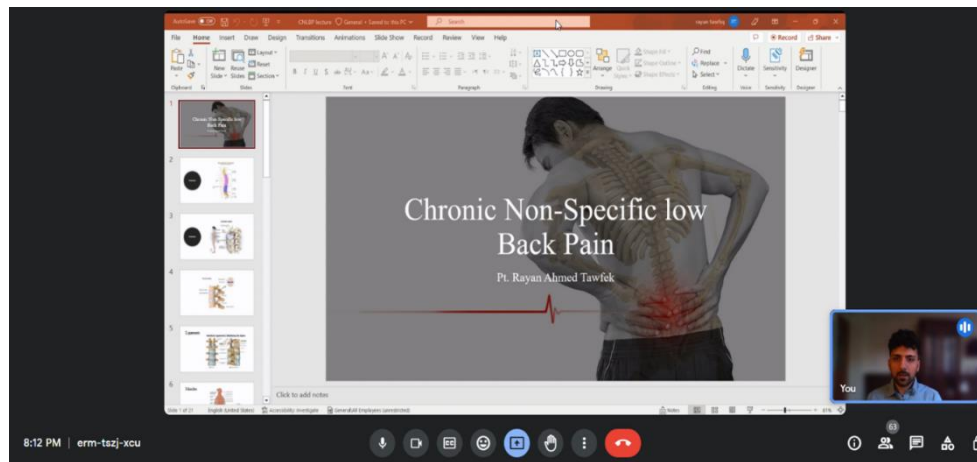


Figure 3.4. Educational Seminar

3.3.2. Real-time synchronized telerehabilitation program

The original plan was to use Xrayfit.com for the intervention however, patients struggled with making an account and register in unfamiliar website. Therefore, for the convenience of all patients, all the sessions were held using ZOOM platform. Room ID and passcode was sent to the patients along with a Word file containing timetable of the sessions for every patient (Figure 3.5). Patients were offered to reschedule their sessions according to their own convenience, also for patients who could not attend their session on time, rescheduling was possible. The sessions were held twice a week for 12 consecutive weeks, the duration of the sessions was 60 minutes. At the beginning of each session patients were reminded to keep their lower back in neutral throughout the session. Then, the therapist demonstrated each exercise while monitoring the patient performing the exercises (figure 3.6, 3.7, 3.8). Comments were made when necessary to correct the patient. The content of the sessions is presented in (Table 3.1).

Patient ID: 1025

Zoom Meeting ID: 2050384437

Zoom Meeting Passcode: [34aHWs](#)

	First Session's Date	Time	Status	Second Session's Date	Time	Status
Week 1	05.06.2023	19.00		09.06.2023	21.30	
Week 2	12.06.2023	19.00		16.06.2023	21.30	
Week 3	19.06.2023	19.00		23.06.2023	21.30	
Week 4	26.06.2023	19.00		30.06.2023	21.30	
Week 5	04.07.2023	19.00		07.06.2023	21.30	
Week 6	11.07.2023	19.00		14.06.2023	21.30	
Week 7	18.07.2023	19.00		21.06.2023	21.30	
Week 8	25.07.2023	19.00		28.06.2023	21.30	
Week 9	01.08.2023	19.00		04.06.2023	21.30	
Week 10	08.08.2023	19.00		11.06.2023	21.30	
Week 11	15.08.2023	19.00		18.06.2023	21.30	
Week 12	22.08.2023	19.00		25.06.2023	21.30	

Figure 3.5. Example of a Patient's Timetable



Figure 3.6. Straight back stretch exercise in group 1



Figure 3.7. Bridge exercise in group 1



Figure 3.8. Quadriceps stretch exercise in group 1

Table 3.1. Content of the exercise program

Exercise Type		Exercises
Warm-up (Week 1,2,3,4,5,6,7,8,9,10,11,12) 5 minutes.		1. Head tilt. (30 seconds) 2. Head rotation. (30 seconds) 3. Shoulder circles. (30 seconds) 4. Chest stretch. (30 seconds) 5. Side bend. (30 seconds) 6. Hip circles. (30 seconds) 7. Torso twist. (30 seconds) 8. Forward bend. (30 seconds) 9. Cat-cow. (1 minute)
	Level one (Week 1,2,3,4) 10 repetitions, 10 seconds rest intervals, 3 sets. 25 minutes in total.	1. Tabletop with single knee and hip flexion. (4 minutes) 2. 4-point kneeling with single leg stretch. (4 minutes) 3. Bridge. (5 minutes) 4. One leg stretch. (4 minutes) 5. Straight leg side lifts. (4 minutes) 6. Sit-ups with lumbar region fixed on the floor. (4 minutes)

Core stabilization exercises	Level two (Week 5,6,7,8) 10 repetitions, 10 seconds rest intervals, 3 sets. 25 minutes in total.	1. Tabletop with step knee and hip flexion. (4 minutes) 2. 4-point kneeling with single-leg rise. (4 minutes) 3. Bridge with leg stretch. (5 minutes) 4. One leg stretch with knee extension. (4 minutes) 5. Straight leg side lifts with contralateral adduction. (4 minutes) 6. Sit-ups reach wrists to knees. (4 minutes)
	Level three (Week 9,10,11,12) 10 repetitions, 10 seconds rest intervals, 3 sets. 25 minutes in total.	1. Tabletop with double knee and hip flexion. (4 minutes) 2. 4-point kneeling with contralateral arm and leg raise. (4 minutes) 3. Bridge with leg stretch and hold. (5 minutes) 4. One leg stretch hold and alternate knee extension. (4 minutes) 5. Straight leg side lifts adduct and hold. (4 minutes) 6. Sit-ups arms crossed over chest. (4 minutes)
Stretching and cool-down (Week 1,2,3,4,5,6,7,8,9,10,11,12) 30 seconds hold for each exercise, 3 cycles. Total of 14 minutes.		1. Quadriceps stretch. (90 seconds) 2. Kneeling hip flexor stretch. (90 seconds) 3. Sitting adductor stretch. (90 seconds) 4. Seated hip and ITB stretch. (90 seconds) 5. Gluteal stretch (in prone position). (90 seconds) 6. Piriformis stretch. (90 seconds) 7. Hamstring-gastrocnemius stretch with a band. (90 seconds) 8. Abdominal stretch. (90 seconds) 9. Bend forward stretch. (90 seconds)

3.3.3. Pre-recording non-synchronized telerehabilitation program

Videos performing and explaining each part of the program were recorded and prepared prior to the beginning of the program. The videos included explanations on how to find the neutral of the lumbar region and how to hold it throughout the exercises (Figure 3.9)

along with warmup (Figure 3.10), Strengthening exercises (Figure 3.11), and Stretching exercises (Figure 3.12). Also, recording of different angles was added where it is needed to ensure that the patients perform exercise the correct way (Figure 3.13, figure 3.14).

Videos were divided into 3 stages and were sent to patients' email addresses through different time periods according to the program's timeframe. The first stage video was sent right after the educational seminar at week 0 followed by stage 2 video in the beginning of week 5, and the 3rd stage video was sent at the end of week 9.

Follow-ups were made once a week either through email address, WhatsApp, or Telegram according to patients' preference. The follow-up was done through texts to check if the patient is performing the exercises and if he/she is facing any problem. The content of the sessions is presented in (Table 3.1).



Figure 3.9. Neutral position demonstration



Figure 3.10. warm-up exercises



Figure 3.11. Table-top exercise in group 2



Figure 3.12. Hamstring-gastrocnemius stretch with a band exercise in group 2



Figure 3.13. Straight back stretching exercise angle 1

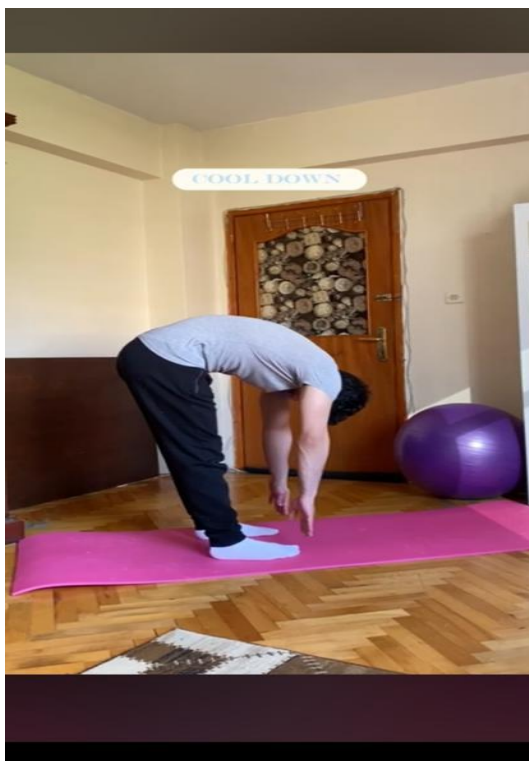


Figure 3.14. Straight back stretching exercise angle 2

3.3.4. Picture aided written instructions, non-supervised home exercise program.

A PDF file was prepared, including a thorough explanation of the program stages, when to perform the exercise, when to move to the next stage, possible risks, and side effects, what to expect from the exercises, how to find the neutral and hold it throughout the exercises. Also, pictures of every movement for every exercise were included in the PDF file according to the program protocol and timeframe (Appendix 9). The PDF file was sent through email address at week 0 right after the educational seminar. In addition, a word file with timetable was sent to record compliance was sent (Appendix 10).

Data Analysis

Statistical analysis was performed with IBM SPSS Statistics 29.0 program. First descriptive statistics was performed to analyze the features of the groups. Kolmogorov–Smirnov test was used to test for normality of distribution. One-Way Analysis

of Variance was used to detect differences between groups. Post-hoc was used to identify the superiority between groups.

Paired t-test was further used to detect the difference between the pre and post result of each group. The level of significance was accepted at $p < 0.05$.



4. RESULTS

72 patients with CNLBP were admitted through online and social media advertisement campaign between January 2023 and May 2023.

The physical features (age, height, weight, and body mass index (BMI) of CNLBP patients are presented in (Table 4.1) There was no significant difference between groups in terms of age, height, weight, and BMI ($p > 0.05$).

Table 4.1. Physical Features of Participants

	Group 1 (n=24)		Group 2 (n=24)		Group 3 (n=24)		P Value
	Mean± S.D.	Median [Min-Max]	Mean ±S.D.	Median [Min-Max]	Mean± S.D.	Median [Min-Max]	
Age	43.21± 12.53	46.50 [19-62]	38.79±1 0.39	38.00 [22-63]	41.79± 10.009	43.50 [21-61]	0.374 ns
Height	169.33 ±8.71	169.50 [155-181]	165.83± 7.48	166.00 [155-179]	166.64 ±7.10	168.50 [155-178]	0.260 ns
Weight	75.63± 10.09	76.50 [60-94]	70.92±6. 90	72.50 [60-82]	70.83± 6.49	70.00 [60-85]	0.066 ns
BMI	26.25± 1.45	25.97 [23.15- 28.69]	25.74±1. 16	25.59 [23.44- 28.01]	25.52± 1.06	25.51 [23.66- 27.76]	0.118 ns

Data expressed as mean ±standard deviation, Median [Min-Max], ns: non-significant, BMI: Body mass index, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Further descriptive group characteristics (Gender, dominant side, other chronic diseases, history of trauma, family history of chronic diseases, and previous participation in training programs) are shown in (Table 4.2). There was no significant difference between groups in terms of gender, dominant side, other chronic diseases, history of trauma, family history and previous participation in training programs ($p > 0.05$).

Table 4.2. Descriptive Group Characteristics

	Group 1 (n=24) %(n)	Group 2 (n=24) %(n)	Group 3 (n=24) %(n)	P value
Gender				0.682
Male	62.5% (15)	50.0% (12)	58.3% (14)	ns
Female	37.5% (9)	50.0% (12)	41.7% (10)	
Dominant Side				0.225
Right	87.5% (21)	95.8% (23)	79.2% (19)	ns
Left	12.5% (3)	4.2% (1)	20.8% (5)	
History of trauma	16.7% (4)	8.3% (2)	16.7% (4)	0.639
				ns
Having family history	100% (24)	100% (24)	100% (24)	
Having other chronic diseases	29.2% (7)	25.0% (6)	16.7% (4)	0.594
				ns
Participants who joined training programs before	16.7% (4)	12.5% (3)	8.3% (2)	0.693
				ns

Data expressed as ns: non-significant, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Descriptive statistics were applied to analyze the characteristics of each group in terms of results for pre-intervention outcome measures. In addition, One Way ANOVA was used to detect significant difference in the results between groups. There were no significant differences in pre intervention results between the study groups ($p > 0.05$).

Description and between groups comparison for pre intervention results of VAS, RMD, ODI, TSK, physical and mental components of SF-12 results are presented in (Table 4.3).

Table 4.3. Pre-intervention descriptive statistics for each group

Outcome measure	Group	Mean±S.D.	Min	Max	P value
VAS	Group 1	6.46±1.74	4	9	0.473 ns
	Group 2	6.33±1.68	4	9	
	Group 3	6.88±1.32	4	9	
RMD	Group 1	12.00±4.25	2	19	0.328 ns
	Group 2	11.13±4.29	7	20	
	Group 3	12.96±4.11	7	20	
ODI	Group 1	30.75±10.36	10	49	0.317 ns
	Group 2	26.29±11.35	11	48	
	Group 3	30.04±10.84	11	49	
TSK	Group 1	39.29±12.26	21	61	0.347 ns
	Group 2	34.42±13.45	17	60	
	Group 3	38.96±12.86	17	60	
PCS	Group 1	33.77±9.20	21.26	49.96	0.173 ns
	Group 2	34.85±9.06	23.38	49.97	
	Group 3	30.51±6.10	24.19	46.57	
MCS	Group 1	37.38±11.95	20.03	56.23	0.419 ns
	Group 2	39.05±11.46	20.06	56.24	
	Group 3	34.98±8.23	20.30	52.84	

Data expressed as ns: non-significant, VAS: visual analog scale, RMD: Roland Morris disability questionnaire, ODI: Oswestry disability index, TSK: Tampa scale for kinesiophobia, PCS: physical component of SF-12, MCS: mental component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: non-synchronized telerehabilitation group, Group 3: home exercise group.

Descriptive statistics were applied to analyze the characteristics of each group in terms of results for post intervention (12th week) outcome measures. In addition, significant

differences were detected among the study groups using One Way ANOVA test, Post Hoc Turkey test was used to detect which group caused the significant difference.

There was a significant difference ($p < 0.05$) indicating the superiority of the Synchronized group over home exercise group in terms of pain levels (VAS), disability status (RMD), fear of movement (TSK), both physical and mental components of SF-12. However, there was no significant difference in the ODI results and there was no significant difference in any of the outcome measures between synchronized and non-synchronized group.

Moreover, there was a significant difference ($p < 0.05$) in terms of quality of life reflected on PCS and MCS between non-synchronized and home exercise group indicating better improvements for patients in non-synchronized group.

Description and between groups comparison for post intervention results of VAS, RMD, ODI, TSK, physical and mental components of SF-12 results are presented in (Table 4.5).

Table 4.4. post-intervention descriptive statistics for each group and between group comparison

		Mean±S.D.	Min	Max	P Value	Post hoc
Post VAS	Group 1	3.08±1.90	0	8	0.018	Group 1 > Group 3
	Group 2	3.54±2.00	0	7		
	Group 3	4.79±2.34	0	9		
Post RMD	Group 1	4.63±4.50	0	18	0.017	Group 1 > group 3
	Group 2	5.67±4.48	0	15		
	Group 3	8.50±5.11	0	20		
	Group 1	16.46±6.09	10	29	0.094	

Post ODI	Group 2	18.00±7.15	10	33		
	Group 3	21.25±9.38	10	41		
Post TSK	Group 1	25.96±10.68	17	60	0.032	Group 1 > group 3
	Group 2	27.75±10.58	17	55		
	Group 3	34.00±11.39	17	59		
Post PCS	Group 1	48.66±7.83	35.39	56.57	0.001	Group 1 > group 2 Group 2 > Group 3
	Group 2	45.99±9.46	31.56	56.57		
	Group 3	38.83±9.87	24.90	68.20		
Post MCS	Group 1	52.62±8.26	34.31	60.75	0.004	Group 1 > group 2 Group 2 > Group 3
	Group 2	50.18±9.63	33.93	60.75		
	Group 3	43.65±10.02	26.30	67.11		

Data expressed as mean ±standard deviation, VAS: visual analog scale, RMD: Roland Morris disability questionnaire, ODI: Oswestry disability index, TSK: Tampa scale for kinesiophobia, PCS: physical component of SF-12, MCS: mental component of SF-12, Min: minimum Max: maximum, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Results demonstrated a trend in the post outcome measures. Individuals in the synchronized group had better improvements than all the other groups reflected in all of the outcome measures. Individuals in the non-synchronized group had better improvements than in the home exercise group. Full results of Turkey HSD test are presented in (Table 4.6). Trends were demonstrated in (graph 4.1, 4.2, 4.3, 4.4, 4.5, 4.6).

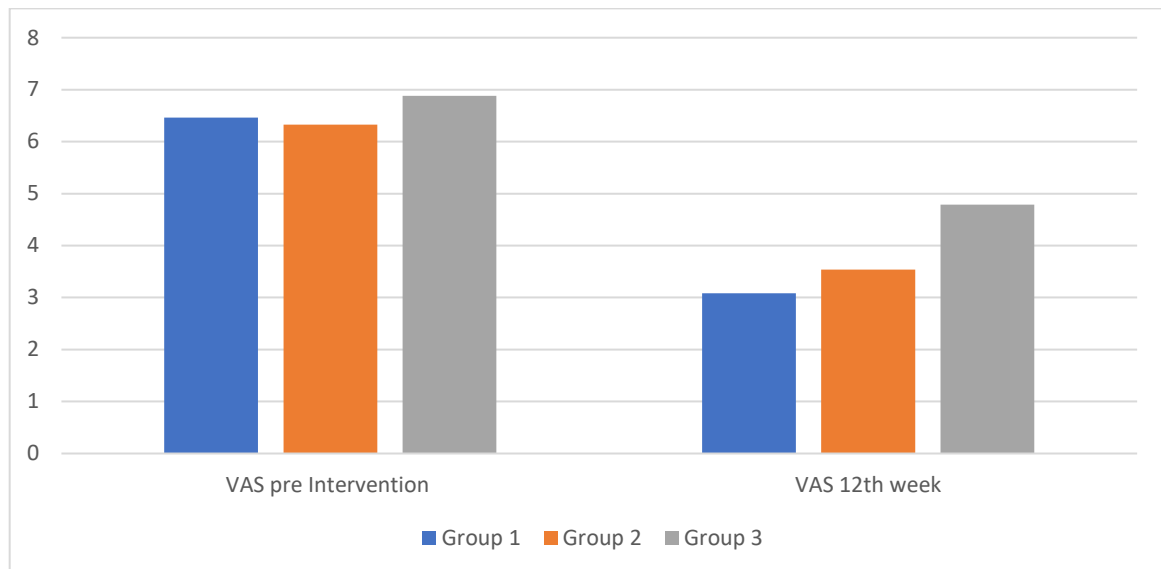
Table 4.5. Multiple comparison results, turkey HSD test

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	P value
Post VAS	Group 1	Group 2	-.458	.729
		Group 3	-1.708*	.017
	Group 2	Group 1	.458	.729
		Group 3	-1.250	.104
	Group 3	Group 1	1.708*	.017
		Group 2	1.250	.104
Post RMD	Group 1	Group 2	-1.042	.725
		Group 3	-3.875*	.016
	Group 2	Group 1	1.042	.725
		Group 3	-2.833	.101
	Group 3	Group 1	3.875*	.016
		Group 2	2.833	.101
Post ODI	Group 1	Group 2	-1.542	.766
		Group 3	-4.792	.084
	Group 2	Group 1	1.542	.766
		Group 3	-3.250	.312
	Group 3	Group 1	4.792	.084
		Group 2	3.250	.312
Post TSK	Group 1	Group 2	-1.792	.837
		Group 3	-8.042*	.034
	Group 2	Group 1	1.792	.837
		Group 3	-6.250	.123

	Group 3	Group 1	8.042*	.034
		Group 2	6.250	.123
Post PCS	Group 1	Group 2	2.67167	.569
		Group 3	9.82875*	.001
	Group 2	Group 1	-2.67167	.569
		Group 3	7.15708*	.022
	Group 3	Group 1	-9.82875*	.001
		Group 2	-7.15708*	.022
Post MCS	Group 1	Group 2	2.44250	.638
		Group 3	8.97167*	.004
	Group 2	Group 1	-2.44250	.638
		Group 3	6.52917*	.047
	Group 3	Group 1	-8.97167*	.004
		Group 2	-6.52917*	.047

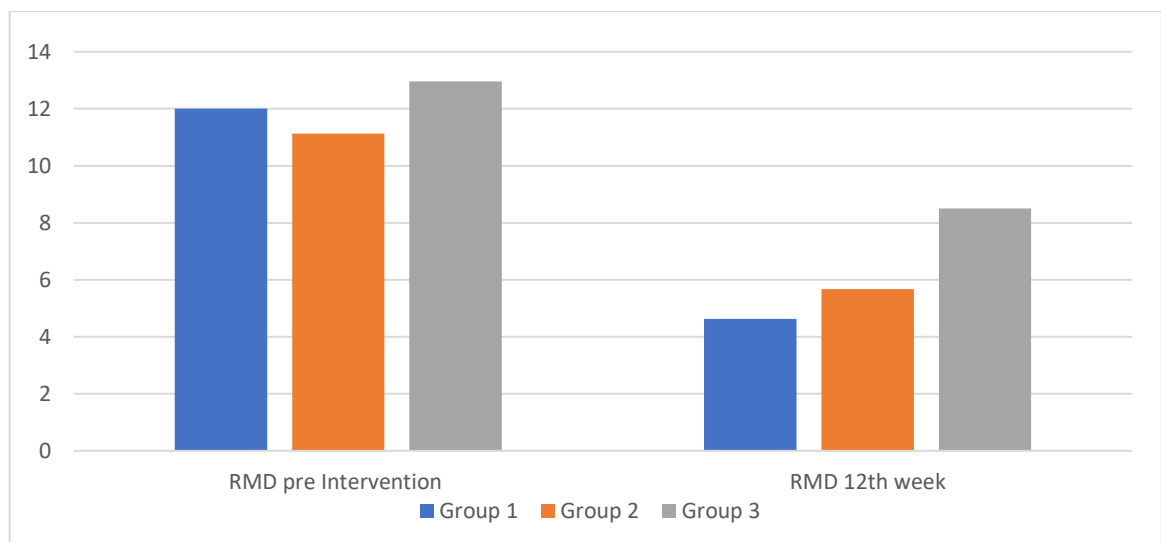
Data expressed as VAS: visual analog scale, RMD: Roland Morris disability questionnaire, ODI: Oswestry disability index, TSK: Tampa scale for kinesiophobia, PCS: physical component of SF-12, MCS: mental component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.1. Comparison of pre intervention and post intervention (12th week) VAS results



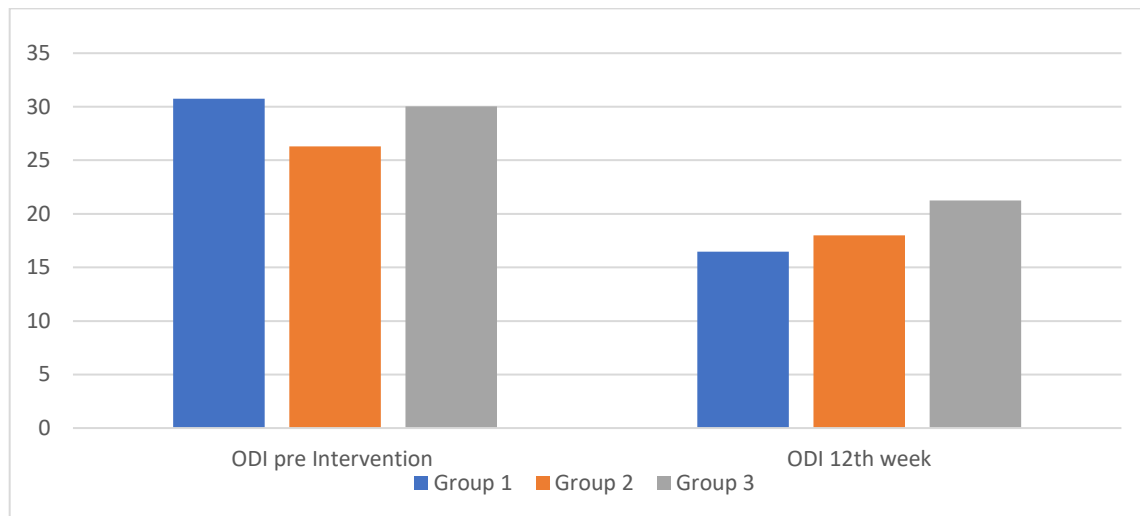
Data expressed as VAS: visual analog scale, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.2. Comparison of pre intervention and post intervention (12th week) RMD results



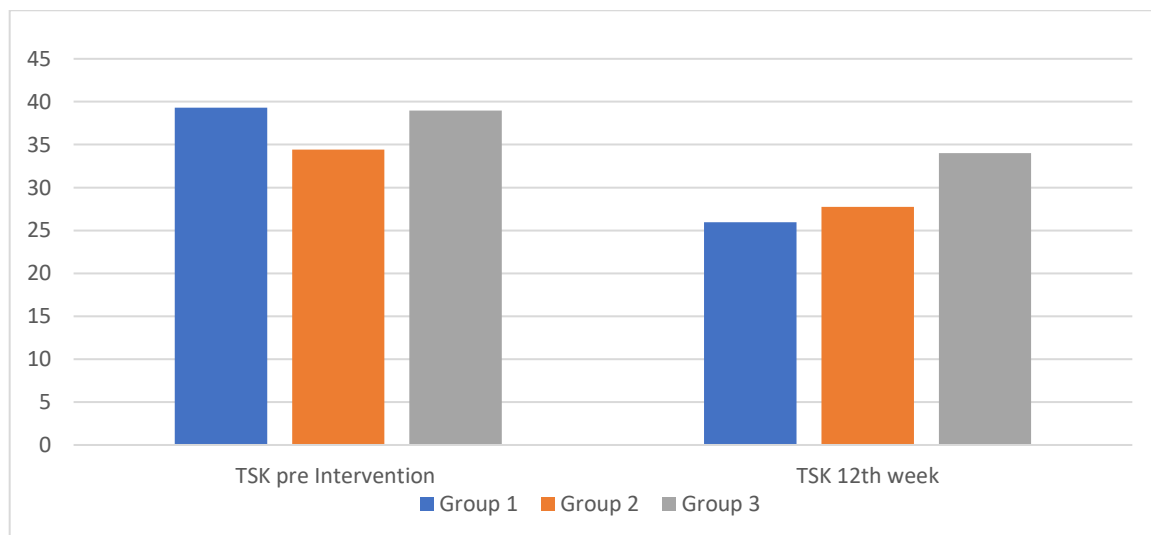
Data expressed as RMD: Roland Morris disability questionnaire, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.3. Comparison of pre intervention and post intervention (12th week) ODI results



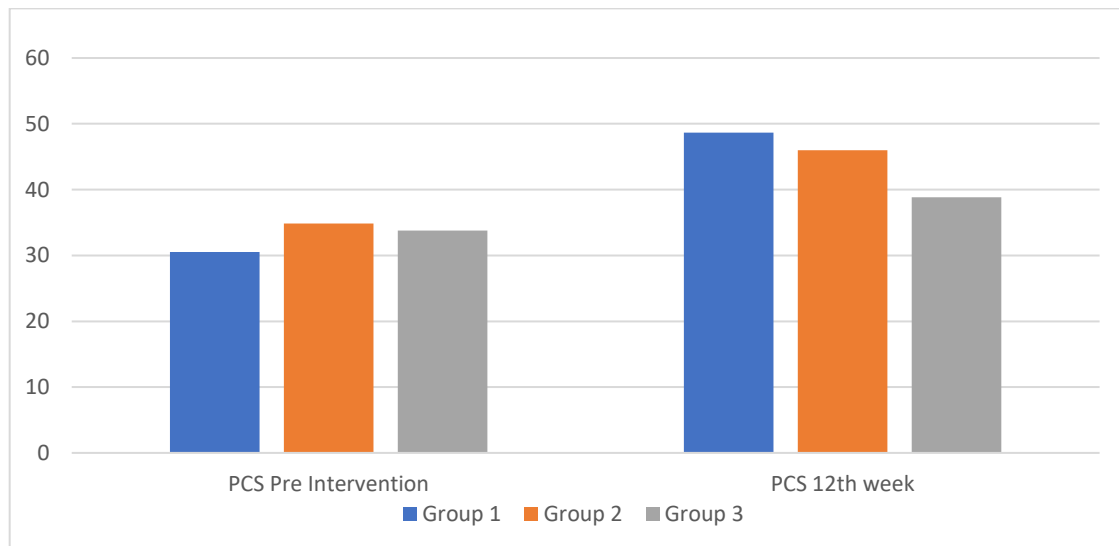
Data expressed as ODI: Oswestry disability index, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.4. Comparison of pre intervention and post intervention (12th week) TSK results



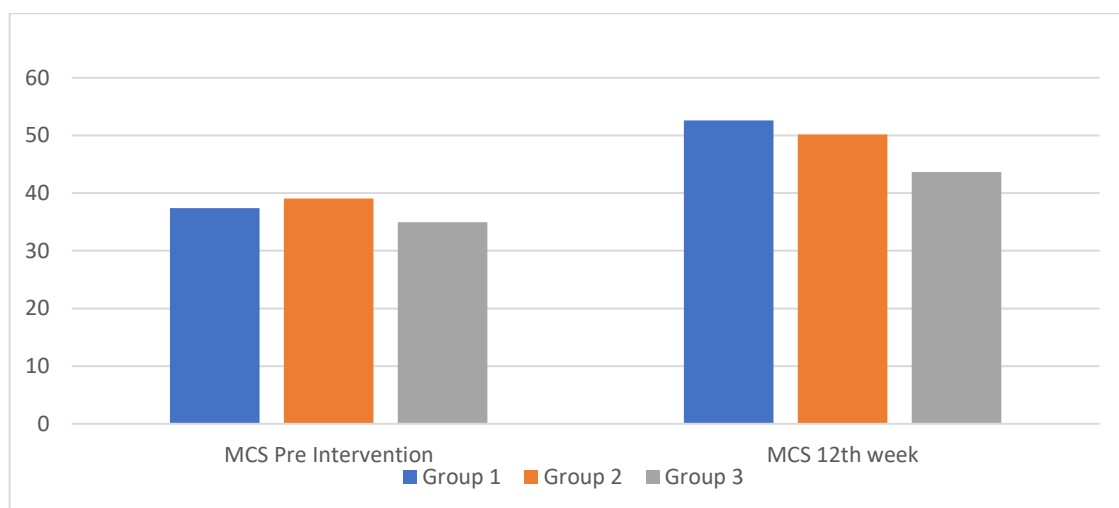
Data expressed as TSK: Tampa scale for kinesiophobia, 12 Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.5. Comparison of pre intervention and post intervention (12th week) PCS results



Data expressed as PCS: physical component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.6. Comparison of pre intervention and post intervention (12th week) MCS results



Data expressed as MCS: mental component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Furthermore, Student t-test was used to detect difference within groups to analyze the improvement in terms of pain, disability status, fear of movement and quality of life. There was a significant difference ($p < 0.05$) between pre intervention (week 0) and post intervention results (12th week) in all the groups.

Comparison of pre and post intervention outcome measures within groups are presented in (Table 4.6). The differences between pre and post intervention results are demonstrated in (Graph 4.7, 4.8, 4.9, 4.10, 4.11, 4.12).

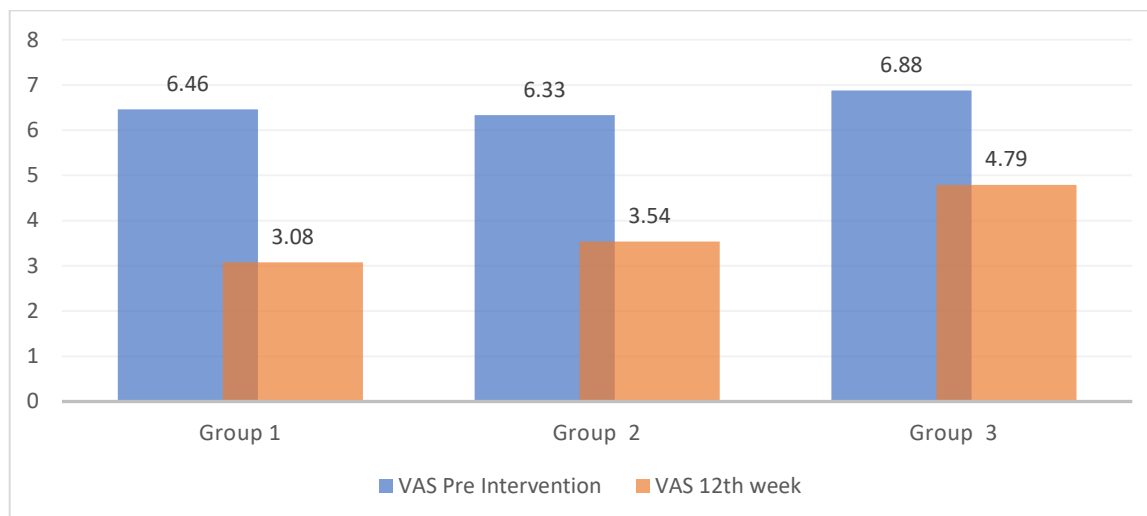
Table 4.6. Comparison of pre and post intervention outcome measures within groups

	Group	Baseline mean $\pm$ S.D.	Post intervention mean $\pm$ S.D.	Mean difference [95% CI]	P value
VAS	Group 1	6.46 $\pm$ 1.74	3.08 $\pm$ 1.90	3.37 [2.86-3.88]	0.001
	Group 2	6.33 $\pm$ 1.68	3.54 $\pm$ 2.00	2.79 [2.19-3.38]	0.001
	Group 3	6.88 $\pm$ 1.32	4.79 $\pm$ 2.34	2.09 [1.39-2.77]	0.001
RMD	Group 1	12.00 $\pm$ 4.25	4.63 $\pm$ 4.50	7.37 [5.71-9.04]	0.002
	Group 2	11.13 $\pm$ 4.29	5.67 $\pm$ 4.48	5.45 [4.15-6.75]	0.001
	Group 3	12.96 $\pm$ 4.11	8.50 $\pm$ 5.11	4.45 [2.55-6.36]	0.003
ODI	Group 1	30.75 $\pm$ 10.36	16.46 $\pm$ 6.09	14.29 [10.95-17.62]	0.001
	Group 2	26.29 $\pm$ 11.35	18.00 $\pm$ 7.15	8.29 [5.17-11.40]	0.001
	Group 3	30.04 $\pm$ 10.84	21.25 $\pm$ 9.38	8.79 [4.96-12.16]	0.001

TSK	Group 1	39.29±12.26	25.96±10.68	13.33 [9.52-17.14]	0.001
	Group 2	34.42±13.45	27.75±10.58	6.66 [3.39-9.94]	0.001
	Group 3	38.96±12.86	34.00±11.39	4.95 [2.50-7.41]	0.001
PCS	Group 1	33.77±9.20	48.66±7.83	14.88 [12.82-16.95]	0.001
	Group 2	34.85±9.06	45.99±9.46	11.14 [8.61-13.66]	0.001
	Group 3	30.51±6.10	38.83±9.87	8.31[5.40-11.23]	0.001
MCS	Group 1	37.38±11.95	52.62±8.26	15.24[12.60-17.89]	0.001
	Group 2	39.05±11.46	50.18±9.63	11.13 [8.89-13.36]	0.001
	Group 3	34.98±8.23	43.65±10.02	8.67 [6.13-11.21]	0.001

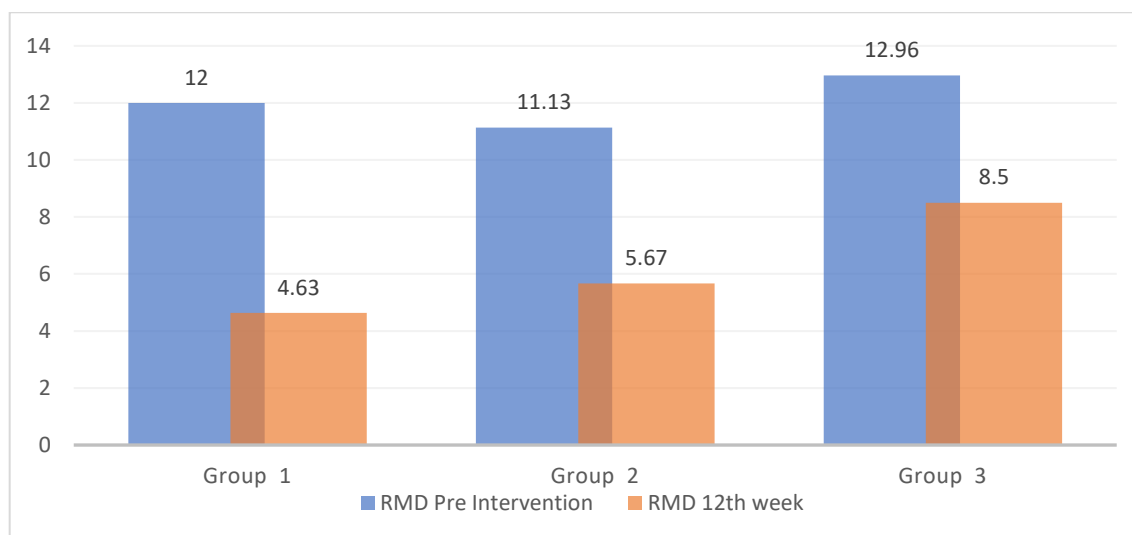
Data expressed as mean ±standard deviation, VAS: visual analog scale, RMD: Roland Morris disability questionnaire, ODI: Oswestry disability index, TSK: Tampa scale for kinesiophobia, PCS: physical component of SF-12, MCS: mental component of SF-12, Min: minimum Max: maximum, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.7. Difference in VAS scores between pre intervention and post intervention (12th week)



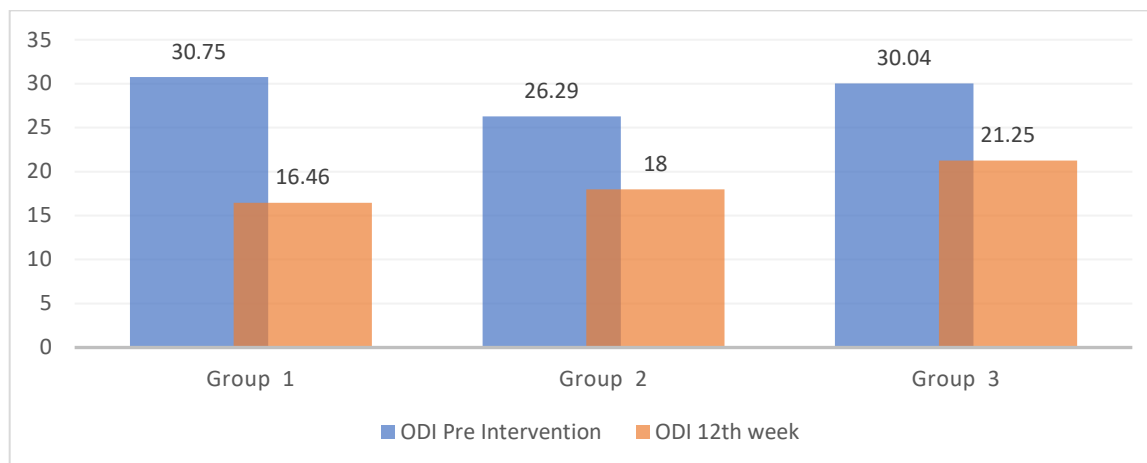
Data expressed as VAS: visual analog scale, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.8. Difference in RMD scores between pre intervention and post intervention (12th week)



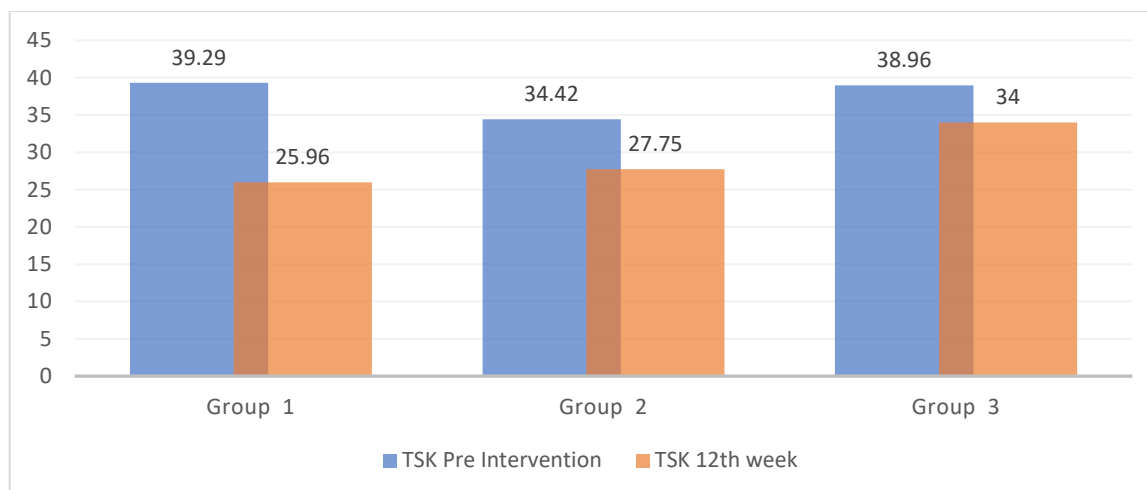
Data expressed as RMD: Roland Morris disability questionnaire, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.9. Difference in ODI scores between pre intervention and post intervention (12th week)



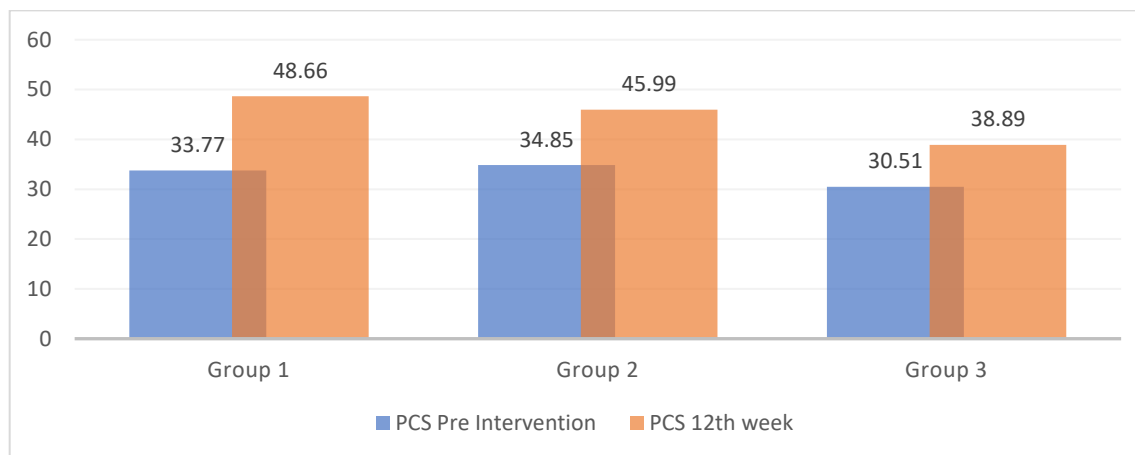
Data expressed as ODI: Oswestry disability index, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.10. Difference in TSK scores between pre intervention and post intervention (12th week)



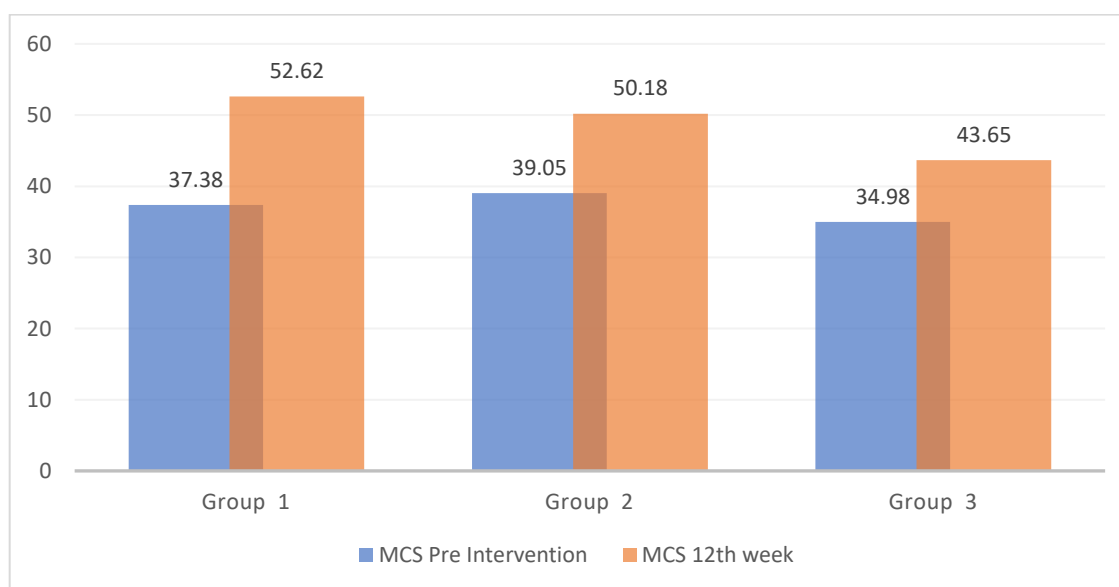
Data expressed as TSK: Tampa scale for kinesiophobia, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.11. Difference in PCS scores between pre intervention and post intervention (12th week)



Data expressed as PCS: physical component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

Graph 4.12. Difference in MCS scores between pre intervention and post intervention (12th week)



Data expressed as MCS: mental component of SF-12, Group 1: synchronized telerehabilitation group, Group 2: Non-synchronized telerehabilitation group. Group 3: Home exercise group.

5. DISCUSSION

Chronic non-specific low back pain (CNLBP) is characterized by persistent pain in between the inferior of the costal margin and above the inferior gluteal folds [96] without specific underlying anatomical or pathological cause for the pain [1]. CNLBP is a multifactorial condition influenced by a combination of biological, psychological, and social factors. Which makes it challenging to diagnose and manage due to its complex and heterogeneous nature. Individuals with CNLBP often experience a range of symptoms, including pain, stiffness, reduced functional capacity, and a negative impact on their overall quality of life [2]. Moreover, CLBP is the most common reason in musculoskeletal disorders for seeking healthcare and can have a substantial impact on individuals and society [2, 3, 4]. It has a relatively high prevalence ranging from 3.9% to 10.2% in the general population [5]. It is estimated that approximately 85-90% of individuals with low back pain fall into this non-specific category [2, 97]. Affecting a significant portion of the global population, CNLBP is considered a prevalent condition with leading cause of disability in individuals younger than 45 years old and is associated with substantial healthcare costs and socioeconomic burden [5, 6] The prevalence of CNLBP can vary across different populations and studies. However, it is estimated that CNLBP affects approximately 60-70% of adults at some point in their lives [1]. There are many treatment options available for CNLBP including invasive intervention for individuals who have not responded to conservative treatments [123] pharmacotherapy [125] CBT and education to self-management [122, 130] orthotics with limited evidence, acupuncture [136] manual therapy techniques such as traction and massage [141, 145] some evidence supporting KT [156] and MFR [146] the use of electrotherapy modalities [138, 139].

In the literature, exercise therapy has been proven to play a crucial role in physiotherapy [165, 169, 170, 173, 185, 188]. Different protocols and exercises programs have been studied. It was found that yoga, Tai chi, Pilates, core stabilization exercise, strengthening and stretching exercises can help in reducing pain, decrease fear of movement, and disabilities in patients with low back pain. The most effective exercise therapy to manage symptoms of CNLBP is still a topic of debate in the literature. However, there is an increased evidences supporting the use of CSE for patients with CNLBP, due to its direct influence on

activating the core and lumbopelvic muscles [18]. In addition, SE facilitates normal spine posture which could result in reducing pressure over the connective tissues and the spinal cord which could lead to reduction in the symptoms of CNLBP [188]. Therefore, combining CSE and SE in one holistic program could yield to better improvements in patients with CNLBP.

Core stabilization exercises has been proven effective for the management of CNLBP in both conventional and telerehabilitation settings. In a single blinded randomized control trial conducted by Muhammed et. al. [173] to study the effectiveness of core stabilization exercises versus routine exercise therapy in management of pain in CNLBP in 120 subjects. Patients were assigned to either core stabilization exercises group or routine exercise therapy. They received one session a week for 6 week. Assessments were done at the beginning of the study and after the 6th week. The results of the study indicates a significant ($p < 0.05$) decrease in pain levels in both study groups. However, CSE was found to be more effective than standard physical therapy exercises in reducing pain levels, with mean change 3.08 point for subjects who performed CSE. In our study we used a combination of core stabilization and stretching exercises. Our results demonstrate significant improvements in pain levels over VAS at the 12th week for all our study groups ($p < 0.05$, Table 4.6). Also, in a review published in 2021 [18] which included 49 articles on the effectiveness of core stability exercises in reducing pain and improving disability in individuals with non-specific chronic low back pain. Indicates that CSE have significant therapeutic benefits for patients with CNLBP, including improving functional disability and enhancing quality of life ($p < 0.05$, Table 4.6). Similarly, the results in our present study demonstrates significant improvements in disability status for all our study groups at the 12th week ($p < 0.05$, Table 4.6). Similarly, all our study groups had a significant improvement in quality of life demonstrated on both parts of the short form SF-12 ($p < 0.05$, Table 4.6). We can confirm that applying CSE plays an important role in reducing pain, disability, and in improving the quality of life for patients with CNLBP.

Stretching exercises (ST) are undeniably effective to manage symptoms for patients with CNLBP. A systematic review and meta-analysis published in the Journal of Orthopaedic & Sports Physical Therapy [188] which analyzed 25 RCTs on exercise interventions for CLBP. The review found that exercise therapy, including stretching and strengthening

exercises, was effective in reducing pain and improving function in patients with chronic low back pain. Another systematic review and meta-analysis [190] published in 2016 assessed the effectiveness of exercise therapy for CLBP. The review included 39 RCTs and found that exercise therapy, particularly stretching exercises, was effective in reducing pain and improving function in patients with chronic low back pain. Our study protocol included 14 minutes of stretching exercises to be performed twice a week for 8 weeks. Results demonstrates a significant improvements for all our study groups in terms of pain levels over VAS at week 12 for all our study groups, and improvement in disability was illustrated on RMD and ODI at the 12th week for all our study groups ($p < 0.05$, Table 4.6). Therefore, we can confirm that stretching exercises play an essential role in reducing pain levels and improving disability levels in patients with CNLPB, especially when combined with CSE.

Telerehabilitation, which is a term used to describe the utilization of information and communication technologies (ICT) to provide rehabilitation services to individuals in remote settings, such as their homes or other environments [191] is a new approach to deliver healthcare services. These services include therapeutic interventions, remote progress monitoring, educational resources, consultations, training, and networking opportunities for individuals with health issues [192]. There are many different modalities used to deliver these interventions for patients with CNLBP with inconclusive results in the literature regarding frequency, repetition, and exercise programs. In a study conducted by Afsaneh Dadarkhah [22], to compare the effectiveness of remote versus in person exercise program for patients with CNLBP which consisted of giving a “detailed written guide” of core stability exercises lasting 45 min including 5 min warmup, 15 min flexibility, 20 min strengthening, and 5 min cool-down exercises for 4 weeks. The participants in the remote exercise group had significant improvement at the end of the study [22] ($p < 0.05$). Our results for the home exercise group agrees with this with significant decrease in pain levels on VAS ($p < 0.05$, Table 4.6). However, the study demonstrated better improvements on ODI than our home exercises group. In addition, the best improvements on ODI was demonstrated by our synchronized remains less than the decrease for participants in the study conducted by Afsaneh. (Table 4.7). This could be caused by condensed exercise regime (45 minutes, two

times a day for four weeks) versus participants in our research which performed 45 minutes of exercise, twice a week for 12 weeks. Controversially, in another study conducted by Fatih Özden [207] to study the efficacy of exercise-based telerehabilitation in CLBP. The study had two groups video exercise-based telerehabilitation (TR), and the other group received paper-based conventional rehabilitation (CR), TR received videos through software called fizyoweb while the other group received paper-based instructions. They were both asked to perform the exercises once a day for 8 weeks. The results for VAS at rest for the TR group dropped 1.6 points after 8 weeks with a similar drop for the CR group 1.4. Our study groups demonstrated significant improvements at the 12th week for all our study groups ($p < 0.05$, Table 4.6). However, our study groups had better improvements in pain and disability levels demonstrated by VAS and ODI results. Nevertheless, this could be related to lower values at baseline for the subjects in the study conducted by Fatih. Similarly, their study groups had less improvement in TSK scores when compared to our study groups (Table 4.7). Therefore, the fear of movements has improved much better with our study groups regardless of close mean scores at baseline our study groups demonstrated better significant improvements ($p < 0.05$, Table 4.6). These improvements might be related to longer exercise programs that our groups received (45 minutes holistic approach) compared to only 7 exercises and ten repetitions for the study groups conducted by Fatih Özden. This also could point out that more holistic approaches with rest days extended for longer period facilitate better improvements in terms of pain, disability, and fear of movement for patients with CNLBP. Moreover, the duration of the program is also controversial and inconclusive when it comes to telerehabilitation for CNLBP. In a study done by Francisco Jesús Villatoro-Luque [208] on 71 patients with CNLBP which included instructions six exercises to be performed twice a week for 8 weeks. The pre and post intervention mean difference in VAS levels were higher than the change for our home exercise group. This could be caused by lower mean of pain levels at the beginning of the study for patients in the study conducted by Francisco. However, our Synchronized and Non-synchronized group had higher reductions in pain levels on VAS scores. Moreover, our study groups had higher reductions in ODI scores compared to the groups in the study by Francisco. The difference in changes could also be caused by the baseline mean difference for ODI scores which was less in Francisco's study. McKenzie therapy was also investigated for telerehabilitation of CNLBP. In a study done by Francis

Fatoye [209] titled “The Clinical and Cost-Effectiveness of Telerehabilitation for People with Nonspecific Chronic Low Back Pain” which included 47 patients to perform McKenzie therapy 3 times a week for 8 weeks. Patients in the home group had a mean difference of 15.71 points on ODI which is higher than the changes for our groups (Table 4.7). This could be related to performing the rehabilitation program 3 times a week versus twice a week for subjects in our study or simply indicate superiority for the McKenzie method for reducing disability levels in patients with CNLBP. However, the study mentioned before didn’t provide enough information about the pre or post interventions results, they only included the change in scores which reduces the reliability of their results. In a similar study carried out by CHIDOZIE E. MBADA [210] which also used Telerehabilitation-Based McKenzie Therapy (TBMT) patients had significant improvements ($p < 0.05$) in VAS pain scores. However, the mean at baseline was 4.29 only. In addition, scores for RMDQ dropped 7.95-point compared to relatively lower scores for our study groups (Table 4.7). However, strangely the change for physical limitation was much less for the study groups compared to our results. Similarly, changes in SF-12 demonstrated by our study groups were much higher with significant difference at the 12th week ($p < 0.05$, Table 4.6). These controversial results could be related to higher scores in baseline results, which were extremely high in the mentioned study for SF-12 results. This might be using the old scoring method for SF-12, whereas we followed the new norm-based scoring method recommended by the owner of SF-12. Myofascial release was also studied for telerehabilitation as a Self-Myofascial release combined core stabilization exercises. In a study conducted by Ufuk et. al. [211] to compare the effects of Self-Myofascial release and combined core stabilization exercises for physiotherapy students with NLBP. The two groups were educated on self-myofascial release in addition to CSE for the intervention group. After 5 weeks the rest pain levels dropped 2.57 points for the intervention group, and 0.85 point only for the control group, which indicates superiority for using CSE alongside Self-Myofascial release technique. However, the sample size in this study is relatively small (28) with a mean age of 25.92 ± 3.26 SD for the intervention group compared to 43.21 ± 12.53 for our synchronized group and relatively similar mean age for the rest of our study groups. In addition, our study groups had significant improvements in VAS and ODI scores at the 12th week with better improvements when compared to the other study ($p < 0.05$, Table 4.6). Therefore, there is limited evidence supporting the benefits of adding

Self-Myofascial release techniques to improve pain or disability for older population through telerehabilitation methods. Lastly, Telephone supported telerehabilitation was considered in literature as well. In a study done to investigate the effectiveness of home-based telephone supported physical activity programs for veterans aged 60 years old or more with CNLBP [212]. Although, the program was for 12 weeks, the improvement in the physical activity group were very low in both groups for the RMDQ when compared to our study groups who showed significant difference at the 12th week ($p < 0.05$, Table 4.6). This could mean that home exercising is not very suitable for the older population, or the protocol used in the mentioned study was not very sufficient.

In our study we used a combination of core stabilization and stretching exercises. Our pre (week 0) and post (week 12) results demonstrated a significant improvements in all outcome measures in all the study groups ($p < 0.05$, Table 4.6). However, there was a significant difference ($p < 0.05$) indicating the superiority of the Synchronized group over home exercise group in terms of pain levels (VAS), disability status (RMD), fear of movement (TSK), both physical and mental components of SF-12. Controversially, there was no significant difference in the ODI results and there was no significant difference in any of the outcome measures between synchronized and non-synchronized group. Moreover, there was a significant difference ($p < 0.05$) in terms of quality of life reflected on PCS and MCS between non-synchronized and home exercise group indicating better improvements for patients in non-synchronized group. Therefore, we can conclude that education, SE and CSE are effective when provided through synchronized video call, prerecorded videos, and through written instruction to reduce pain, disability, fear of movement, and improve quality of life with superiority to both synchronized video calls and prerecorded videos.

Telerehabilitation is a novel concept that we as scientists and researchers need to investigate more. For patients struggling with LBP there are many effective management programs that can be delivered through online basis. In the literature, Self-Myofascial release and Telerehabilitation-Based McKenzie Therapy (TBMT) demonstrate good improvements on pain levels and disability levels for patients with CLBP. Moreover, the evidences supporting the use of CSE and SE through telerehabilitation programs are more conclusive with patients showing improvements after a few weeks of rehabilitation. However, the best

frequency, duration and repetitions of these programs are still up to debate. Although to the best of our knowledge this study is the first study to compare real-time synchronized telerehabilitation, with non-synchronized pre-recorded videos telerehabilitation and home exercise control group for patients with CNLBP. But our study has limitations. The limitation for our study was not including long term follow ups to detect long term effects on the study groups. In addition, internet connection and struggle with technology, especially for older patients, was a limiting factor for some of the real-time video call sessions.



6. CONCLUSION

- Real-time synchronized tele-rehabilitation program, pre-recorded non-synchronized telerehabilitation program, Picture aided digital book based telerehabilitation program are an effective intervention method to reduce pain, disability, fear of movement, and improve the over quality of life for patients with CNLBP.
- Synchronized telerehabilitation is superior to the non-synchronized telerehabilitation method in terms of pain, disability, fear of movement reduction and improving the quality of life for patients with CNLBP.
- Non-synchronized is superior to the digital book telerehabilitation method in terms of pain, disability, fear of movement reduction and improving the quality of life for patients with CNLBP.
- Patients should be advised to have a strong internet connection for the synchronized real-time video calls, to prevent delay and inconsistency within the session.
- Synchronized real-time video call, pre-recorded videos, and picture aided written instructions should be used to reduce pain, disability, fear of movement, and improve the over quality of life for patients with CNLBP.

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APPENDIX 1. ETHICAL APPROVAL



**T.C.
MARMARA ÜNİVERSİTESİ
Sağlık Bilimleri Fakültesi
Girişimsel Olmayan Klinik Çalışmalar Etik Kurulu**

PROJENİN ADI	: “Kronik Non-spesifik Bel Ağrısında Senkronize Ve Senkronize Olmayan Telerehabilitasyon Programlarının Ağrı, Hareket Korkusu ve Yaşam Kalitesinin Üzerine Etkilerinin İncelenmesi”
PROJENİN YÜRÜTÜCÜSÜ	: Dr. Öğr. Üyesi Elif Tuğçe ÇİL
PROJEDEKİ ARAŞTIRICILAR	: Rayan Ahmed TAWFEK
ONAY TARİHİ VE SAYISI	: 25.05.2023/70

Sayın: Dr. Öğr. Üyesi Elif Tuğçe ÇİL

“70” protokol numaralı “Kronik Non-spesifik Bel Ağrısında Senkronize Ve Senkronize Olmayan Telerehabilitasyon Programlarının Ağrı, Hareket Korkusu ve Yaşam Kalitesinin Üzerine Etkilerinin İncelenmesi” İsimli projeniz Fakültemiz Etik Kurulu tarafından incelenmiş oy birliği ile etik yönden uygun olduğuna karar verilmiştir.

APPENDIX 2. CONSENT FORM

Consent Form

INFORMED CONSENT FORM

Title of our study:

Investigation of the Effectiveness of Synchronized and Non-synchronized Telerehabilitation Programs for Chronic Non-specific Low Back Pain.

Dear Participant, this study is master thesis research. This research is carried out by Yeditepe University, Faculty of Health Sciences, Physiotherapy and Rehabilitation Department. The research will be conducted on people aged between 18 and 65 who have a medical diagnosis of chronic non-specific low back pain. During the research, application methods such as drugs, injections, incisions or diagnostic procedures such as x-ray, magnetic resonance and blood sampling will not be used.

The aim of the study is to determine the effects of remote administration of the methods applied in physiotherapy to those with chronic non-specific low back pain, to objectively evaluate the effectiveness of different treatment methods applied to individuals with chronic non-specific low back pain, and to compare the effects of the methods with each other. By accepting to participate in our research, you will contribute to finding better and more accessible treatment option for people who share the same condition as you. Therefore, your participation in this study or your consent to participate in this treatment program is of great importance both for us as healthcare professionals and for individuals with chronic non-specific low back pain.

General Information About the Study:

- The estimated number of volunteers expected to participate in our research is 72. There will be three different groups in our research. Volunteers with chronic non-specific low back pain who agreed to participate in the study will be randomly assigned into three different groups.
- If you agree to participate in the study, you can participate in your treatment remotely/online from anywhere. Your condition will be assessed by answering questionnaires at the beginning of the research, and again after the end of the research to determine the effectiveness of the treatment.
- Estimated Time for the Research Your treatment will last 8 weeks. You must carry out the treatment 2 days a week for 8 weeks.

Actions to be Taken within the Scope of the Study / Actions to be Taken During the Evaluation

Your age, height, weight, occupation, dominant side, marital status, educational status, main complaint, history, previous surgical operation, personal and family health history information and the medications you use will be recorded. Before the first session and after the last session, the degree of pain intensity you feel in the back, the degree of disability due to low back pain, fear of movement due to low back pain, quality of life and how satisfied you are at the end of the research will be evaluated by filling out the questionnaires.

Questionnaires are short questions and will take you a short time to complete. It is important that you answer all of the questions asked in the questionnaire sincerely and accurately. No

comments will be made to you and no negative behavior will be made regarding your answers to the questions. While filling out the survey, you do not have to answer the questions you do not want to or you can simply end the survey.

Five different questionnaires will be used in our study.

1. The "visual analog scale", which is our primary questionnaire, it is a vertical 100 mm long line with numbers from 0 to 10. For the value to be measured, you are asked to mark the point that describes your pain intensity the most. It is used to assess pain. A value of 0 means "no pain", a value of 10 means "unbearable pain" and you can express your pain numerically by marking the pain value you feel among them.
2. The "Roland-Morris Disability Questionnaire" is used to measure disability in patients with chronic non-specific low back pain. It includes a 24-item scale with a total score ranging from 0 (no disability) to 24 (high disability).
3. The Oswestry Disability Index, evaluates disability in 10 different categories: pain severity, personal care, lifting, walking, sitting, standing, sleeping, social life, sexual life, and travel. Each statement is scored from 0 to 5, with higher scores indicating more disability.
4. The "Tampa Kinesiophobia Scale", is a questionnaire that evaluates fear of movement and re-injury. In the questions in the survey, you are asked to mark the most appropriate option for you.
5. SF-12 Health Questionnaire: is a questionnaire that measures the quality of life, by assessing the impact of health on everyday activities. It uses the same eight domains as the SF-36: limitations in physical activities because of health problems, limitations in social activities because of physical or emotional problems, limitations in usual role activities because of physical health problems, bodily pain, general mental health (psychological distress and well-being), limitations in usual role activities because of emotional problems, vitality (energy and fatigue), general health perceptions

Information from surveys will remain confidential and will only be used for research purposes (or "scientific purposes").

Procedures During Treatment

All groups will be given the same rehabilitation program with a different method.
Content of the rehabilitation program

- Video conferencing training. The content of the session is the anatomy and physiology of the musculoskeletal structure and the kinesiology of the lumbar region. In addition, education will be given on the principles of pain, possible causes of chronic non-specific low back pain and how to manage it (correct posture and life changes).
- Strengthening exercises.
- Stretching exercises.

Risks That May Occur During Evaluation or Treatment: If the exercise methods or applications to be used in this program are done correctly, you will not feel pain or might feel very mild discomfort. The prescribed exercises do not cause any damage to the joints, muscles or other structures and is planned according to your health condition. As you continue the treatment, the range of motion will increase, your pain will decrease and your daily life will be easier.

Alternatives to the Treatment to be Applied: There is no standard physiotherapy program accepted in the world for the treatment of patients who share the same condition as you. Therefore, many physiotherapy programs are implemented. The aim of the study is to determine how effective the exercise method, which provides the contraction of the deep muscles around the waist and hips, which is one of the most useful methods in the clinic, and which method is more effective in patients who share the same situation with you. In addition, different applications and exercise types in the field of physiotherapy are applied to patients who share the same health problem as you. As a result of these treatment methods, there will be a permanent decrease in your pain and an increase in your functions over time.

Protecting information about your identity and health: No personal identification information such as surname, initials or date of birth will be collected for the study. Your name will not be disclosed outside the research clinic unless required by law. In order to protect your identity, the physiotherapist in charge of the research will replace your data with a special code that will identify it. Only the physician, consultant and physiotherapist involved in the research can associate this code with your personal information. During the study, your code and health data will be recorded in an encrypted computer and an encrypted program. The data is recorded in a classified environment where no one is present. Therefore, it is out of the question for anyone from the public to have access to this information. However, in terms of the health of the research, the principal investigator or co-responsible persons, the members of the ethics committee of the study, the audience, the examiners and other relevant health authorities will have direct access to your original medical records (doctor examination findings, hospital health procedures such as your tests) in terms of the health of the research. . However, even when your medical records are accessed, your identity and health information will be kept confidential. Except for the persons involved in the research mentioned above, no one will be able to access your information. The persons in charge (Author or co-author persons, members of the ethics committee of the research, the research institution we work with and other relevant health institutions) are official persons who will never share your data with other people and will check the accuracy of the research.

The data obtained as a result of our research can be used for publication purposes while the study continues or in the future. When the data is used for publication purposes, the records of your identity and contact information will never be shared with the public, an unofficial institution or anyone who is not involved in our research. Your data is under the guarantee of the persons in charge of the study. By signing the written informed consent form or consent form, you or your legal representative will have authorized such access.

You or your legal representative will be notified in a timely manner when new information becomes available regarding the research subject or that may affect your willingness to continue participating in the research. You will be notified if there is no reasonably targeted clinical benefit for you to continue your participation in the trial.

Your participation in the research is on a voluntary basis. If you refuse to participate in the research, **you will not be subject to any penalties or sanctions, and you will not lose any of your rights.** If you agree to participate in the study, no fee will be charged from you. Hence, you will not be charged a fee and your physical therapy fee will not be invoiced to SSI; therefore, there will be no reduction in your right to receive annual physiotherapy sessions. Thus, you will have the right to receive treatment again from the health institution of your

choice. You will have the right to withdraw from the study at any time. When you withdraw from the research, you will not be penalized, you will not face any different behavior and you will not lose any of your rights.

If you agree to participate in the study voluntarily, you will be excluded from the study if you do not continue your treatment for 8 weeks. If you have a question about your rights as a

1. Participant's statement *

Check all that apply.

☐ The above information about this research was conveyed to me by the research team officer, stating that a study will be conducted at Yeditepe University Faculty of Health Sciences, Department of Physiotherapy. After this information, I was invited as a participant to such a study. I have read and understand the 5 pages of written information about this study. Working procedures were explained to me and I was given sufficient time to ask questions. I have been given sufficient confidence that my personal information will be carefully protected during the use of the study results for educational and scientific purposes. I give permission to the physician, the Ethics Committee/Regulatory Authorities (and others mentioned in the section entitled "How will information about my identity and health be protected?") access to my data as described in this information sheet.

☐ I did not take any financial offers to participate in this study. I will not be paid for participating in the study. If I encounter a problem with the research during the study, at any hour, I know that I can contact the research officer Pt. Rayan Ahmed Tawfek,

I am not required to participate in this study and may not. I have not encountered any compelling behavior about my participation in the study. I know that when I agree to participate in the research voluntarily, I can leave the research at any time with or without justification.

☐ I understand all the explanations made to me. After a certain period of reflection on my own, I decided to take part in this study as a participant. I accept this invitation with great satisfaction and willingness. I understand that my consent is valid unless it is revoked by me. A copy of this signed form paper will be given to me if I request it.

2. Name and Surname *

3. Email address *

4. Phone number (please include country code)
ex: 0090

5. Date *

Example: January 7, 2019

6. I am the person mentioned in the date stated above hereby agree on being a part *
of this research

Check all that apply.

☐ I accept



APPENDIX 3. GENERAL DEMOGRAPHICS AND HISTORY

7. Age *

8. Height *

9. Weight *

10. BMI

11. Gender

12. Dominant side *

Mark only one oval.

☐ Right

☐ Left

13. Do you have any chronic disease other than low back pain?

If yes please mention it

14. Does your family have a history of any chronic disease?

If yes please mention it

15. Did you ever suffer from a traumatic injury?
If yes please mention it

16. Did you ever practice any type of sport or a specific physical training program?
If yes please mention it



APPENDIX 4. VISUAL ANALOG SCALE

Visual Analog scale

17. From 0 to 10 how much would you rate your low-back pain? *

The Visual Analog Scale (VAS) is a horizontal line with tick marks from 0 to 10. The line is color-coded: green for 0-3, yellow for 4-6, and red for 7-10. Below the line, there are six categories with corresponding smiley faces: 'No Pain' (green face, 0), 'Mild' (light green face, 1-3), 'Moderate' (yellow face, 4-6), 'Severe' (orange face, 7-9), 'Very Severe' (dark orange face, 8-9), and 'Worst Pain Possible' (red face, 10). Below the categories, there is a row of 11 ovals for marking the rating, corresponding to numbers 0 through 10. The instruction 'Mark only one oval.' is written above the ovals.

0 1 2 3 4 5 6 7 8 9 10

No Pain Mild Moderate Severe Very Severe Worst Pain Possible

0 1-3 4-6 7-9 10

Mark only one oval.

0 1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

APPENDIX 5. ROLAND MORRIS DISABILITY QUESTIONNAIRE

Roland Morris Disability Questionnaire

When
your back hurts, you may find it difficult to do some of the things you
normally do.

This list contains sentences that
people have used to describe themselves when they have back pain. When you read them,
you may find that some
stand out because they describe you *today*.

As you read the list, think of
yourself *today*. When you read a sentence that describes you
today, put a tick against it. If the
sentence does not describe you, then leave the space blank and go on to the
next one. Remember, only tick the
sentence if you are sure it describes you today.

18. Only tick the sentence if you are sure it describes you today

Check all that apply.

- ☐ I stay at home most of the time because of my back.
- ☐ I change position frequently to try and get my back comfortable.
- ☐ I walk more slowly than usual because of my back.
- ☐ Because of my back I am not doing any of the jobs that I usually do around the house.
- ☐ Because of my back, I use a handrail to get upstairs.
- ☐ Because of my back, I lie down to rest more often.
- ☐ Because of my back, I have to hold on to something to get out of an easy chair.
- ☐ Because of my back, I try to get other people to do things for me.
- ☐ I get dressed more slowly than usual because of my back.
- ☐ I only stand for short periods of time because of my back.
- ☐ Because of my back, I try not to bend or kneel down.
- ☐ I find it difficult to get out of a chair because of my back.
- ☐ My back is painful almost all the time.
- ☐ I find it difficult to turn over in bed because of my back.
- ☐ My appetite is not very good because of my back pain.
- ☐ I have trouble putting on my socks (or stockings) because of the pain in my back.
- ☐ I only walk short distances because of my back.
- ☐ I sleep less well because of my back.
- ☐ Because of my back pain, I get dressed with help from someone else.
- ☐ I sit down for most of the day because of my back.
- ☐ I avoid heavy jobs around the house because of my back.
- ☐ Because of my back pain, I am more irritable and bad tempered with people than usual.
- ☐ Because of my back, I go upstairs more slowly than usual.
- ☐ I stay in bed most of the time because of my back.

APPENDIX 6. OSWESTRY DISABILITY INDEX

Oswestry Disability Index

This questionnaire is designed to give us information as to how your back (or leg) trouble affects your ability to manage in everyday life.

Please answer every part. Mark one box only in each part that most closely describes you today.



19. Pain intensity

Mark only one oval.

- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

20. Personal care (washing, dressing, etc.)

Mark only one oval.

- ☐ I can look after myself normally without causing additional pain.
- ☐ I can look after myself normally but it is very painful.
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of my personal care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

21. Lifting

Mark only one oval.

- ☐ I can lift heavy weights without additional pain.
- ☐ I can lift heavy weights but it gives me additional pain.
- ☐ Pain prevents me from lifting heavy weights off the floor but I can manage if they are conveniently positioned, e.g. on a table.
- ☐ Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.
- ☐ I can only lift very light weights.
- ☐ I cannot lift or carry anything at all.

22. Walking

Mark only one oval.

- ☐ Pain does not prevent me from walking any distance.
- ☐ Pain prevents me from walking more than one mile.
- ☐ Pain prevents me from walking more than a quarter of a mile.
- ☐ Pain prevents me from walking more than 100 yards.
- ☐ I can only walk using a cane or crutches.
- ☐ I am in bed most of the time and have to crawl to the toilet.

23. Sitting

Mark only one oval.

- ☐ I can sit in any chair as long as I like.
- ☐ I can sit in my favorite chair as long as I like.
- ☐ Pain prevents me from sitting for more than 1 hour.
- ☐ Pain prevents me from sitting for more than half an hour.
- ☐ Pain prevents me from sitting for more than 10 minutes.
- ☐ Pain prevents me from sitting at all.

24. Standing

Mark only one oval.

- ☐ I can stand as long as I want without additional pain.
- ☐ I can stand as long as I want but it gives me additional pain.
- ☐ Pain prevents me from standing for more than 1 hour.
- ☐ Pain prevents me from standing for more than half an hour.
- ☐ Pain prevents me from standing for more than 10 minutes.
- ☐ Pain prevents me from standing at all.

25. Sleeping

Mark only one oval.

- ☐ My sleep is never interrupted by pain.
- ☐ Sleep is occasionally interrupted by pain.
- ☐ Because of pain I have less than 6 hours sleep.
- ☐ Because of pain I have less than 4 hours sleep.
- ☐ Because of pain I have less than 2 hours sleep.
- ☐ Pain prevents me from sleeping at all.

26. Sex life (if applicable)

Mark only one oval.

- ☐ My sex life is normal and causes no additional pain.
- ☐ My sex life is normal but causes some additional pain.
- ☐ My sex life is nearly normal but is very painful.
- ☐ My sex life is severely restricted by pain.
- ☐ My sex life is nearly non existent because of pain.
- ☐ Pain prevents me from having any sex life at all.

27. Social life

Mark only one oval.

- ☐ My social life is normal and causes me no additional pain.
- ☐ My social life is normal but increases the degree of pain.
- ☐ Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g. sport, etc.
- ☐ Pain has restricted my social life and I do not go out as often.
- ☐ Pain has restricted my social life to home.
- ☐ I have no social life because of pain.

28. Traveling

Mark only one oval.

- ☐ I can travel anywhere without pain.
- ☐ I can travel anywhere but it gives me additional pain.
- ☐ Pain is bad but I am able to manage trips over two hours.
- ☐ Pain restricts me to trips of less than one hour.
- ☐ Pain restricts me to short necessary trips of under 30 minutes.
- ☐ Pain prevents me from traveling except to receive treatment.



APPENDIX 7. TAMPA SCALE FOR KIENSOPHOBIA

Tampa Scale for Kinesiophobia

In these days of high-tech medicine, one of the most important sources of information about you is often missing from your medical records: your own feeling or intuitions about what is happening with your body. We hope that the following information will help to fill that gap

Please answer the following questions according to your true feelings, not according to what others think you should believe. Score each statement from strongly disagree to strong agree by tapping the appropriate box.

29. I'm afraid that I might injury myself
if I exercise

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree



30. If I were to try to overcome it, my pain would increase.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

31. My body is telling me I have something dangerously wrong

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

32. My pain would probably be relieved if I were to exercise.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

33. People aren't taking my medical condition seriously enough.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

34. My accident has put my body at risk for the rest of my life.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

35. Pain always means I have injured my body.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

36. Just because something aggravates my pain does not mean it is dangerous.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

37. I am afraid that I might injure myself accidentally.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

38. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

39. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

40. Although my condition is painful, I would be better off if I were physically active

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

41. Pain lets me know when to stop exercising so that I don't injure.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

42. It's really not safe for a person with a condition like mine to be physically active.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

43. I can't do all the things normal people do because it's too easy for me to get injured.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

44. Even though something is causing me a lot of pain, I don't think it's actually dangerous.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

45. No one should have to exercise when he/she is in pain.

Mark only one oval.

- ☐ Strongly disagree
☐ Somewhat disagree
☐ Somewhat agree
☐ Strongly agree

APPENDIX 8. SF-12 QUALITY OF LIFE QUESTIONNAIRE

SF-12 Health Questionnaire

This survey asks for your views about your health.

This information will help keep track of how you feel and how well you are able to do your usual activities. *Thank you for completing this survey!*

For each of the following questions, please mark one box that best describes your answer.

46. In general, would you say your health is

Mark only one oval.

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

47. The following questions are about activities you might do during a typical day.
Does your health now limit you in these activities? If so, how much?

Moderate activities, such as moving a table, pushing
a vacuum cleaner, bowling, or playing golf

Mark only one oval.

- ☐ Yes, limited a lot
☐ Yes, limited a little
☐ No, not limited at all

48. The following questions are about activities you might do during a typical day.
Does your health now limit you in these activities? If so, how much?

Climbing several flights of stairs

Mark only one oval.

- ☐ Yes, limited a lot
☐ Yes, limited a little
☐ No, not limited at all

49. During the past week, how much of the time have you had any of the following
problems with your work or other regular daily activities as a result of your physical
health?

Accomplished less than you would like

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

50. During the past week, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

Were limited in the kind of work or other activities

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

51. During the past week, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

Accomplished less than you would like

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

52. During the past week, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
Did work or other activities less carefully than usual

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

53. During the past week, how much did pain interfere with your normal work (including both work outside the home and housework)?

Mark only one oval.

- ☐ Not at all
☐ A little bit
☐ Moderately
☐ Quite a bit
☐ Exteremly

54. These questions are about how you feel and how things have been with you during the past week. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past week...

Have you felt calm and peaceful?

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

55. These questions are about how you feel and how things have been with you during the past week. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past week...

Did you have a lot of energy?

Mark only one oval.

- ☐ All of the time
☐ Most of the time
☐ Some the time
☐ A little of the time
☐ Non of the time

56. These questions are about how you feel and how things have been with you during the past week. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past week...

Have you felt downhearted and depressed?

Mark only one oval.

- ☐ All of the time
- ☐ Most of the time
- ☐ Some the time
- ☐ A little of the time
- ☐ Non of the time

57. During the past week, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

Mark only one oval.

- ☐ All of the time
- ☐ Most of the time
- ☐ Some the time
- ☐ A little of the time
- ☐ Non of the time

APPENDIX 9. HOME EXERCISE DIGITAL BOOK



YEDİTEPE UNIVERSITY, FACULTY OF HEALTH SCIENCES, DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

Home based exercise

In this booklet, you will find thorough therapeutic exercises for chronic non-specific low back pain.

This program is designed for your specific condition. If you follow the program correctly you will notice a permanent reduction in your pain levels, increase in your range of motion and reduction in your fear of movement over time.

The program contains warm-up exercises, cool down/stretching exercises and 3 stages of core stabilization exercises. Please follow the instructions carefully and correctly for the duration of your treatment which is 12 consecutive weeks. You must perform these exercises twice a week with at least one day interval between sessions. Avoid doing heavy work the day after your workout session, to give your muscles enough time to recover.

It is normal to feel discomfort during performing the exercises. However, if you feel a sudden increase in pain during or right after the treatment session, STOP immediately and contact the number or email address written on the consent form you signed.

Warm-up exercises

You should perform these exercises every time prior to your strengthening program. If performed correctly, your muscles will be ready for loading which will decrease the risk of having spasms during and after the workout. Also, it will speed up your recovery time.

The warmup should not last more than 5 minutes and not less than 3 minutes.

Please follow the instructions carefully and correctly!

The exercises must be done slowly, correctly, and in a controlled manner.

1) Head tilt. (30 seconds)

- Starting position: Hold your head still. Without pushing your head to the back, tuck your chin inward a little.



- First movement: tilt your head to the right by getting your right ear closer to your right shoulder without moving your shoulder. Note, your ear will not touch your shoulder just get it as close as possible without forcing it.
- Go back to the starting position.
- Second movement: tilt your head to the left by getting your right ear closer to your left shoulder without moving your shoulder. Note, your ear will not touch your shoulder just get it as close as possible without forcing it.
- Repeat for 30 seconds.



2) Head rotation. (30 seconds)

- Starting position: Hold your head still. Without pushing your head to the back, tuck your chin inward a little.
- Look down without touching your chin with your chest. In a circular motion slowly look at the floor to your right, then to your right, look up without forcing your head back, look to your left, look at the floor to your left, look down without touching your chin with your chest. Go back to the starting position.
- Repeat starting from the left side.
- Alternate the movement one starting from the right and one from the left for 30 seconds.
- Note: to avoid dizziness perform the exercise very slowly.



3) Shoulder circles. (30 seconds)

- Starting position: Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little. Open your arms 90 degrees to the sides.
- Perform small circles by moving your shoulders a little bit up, forward, down, backward.
- Repeat for 30 seconds.



4) Chest stretch. (30 seconds)

- Starting position: Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little. Open your arms 90 degrees in front of you with your palms facing each other.
- Open your arms to the sides and a little bit backward.
- Go back to the starting position.
- Repeat for 30 seconds.



5) Side bend. (30 seconds)

- Starting position: Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little. Rest your arms to your sides.
- First with your right hand reach the lateral side of your right knee.
- Go back to the starting position.
- with your left hand reach the lateral side of your left knee.
- Go back to the starting position.
- Repeat for 30 seconds.



6) Hip circles. (30 seconds)

- Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little. Place your hands over your hip.
- Without moving your legs. Push your hip to the right and perform a circle from right to left by pushing your hip forward. Then from the left to the right by pushing your hip backward.
- Alternate the movement for 30 seconds.



7) Torso twist. (30 seconds)

- Starting position: Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little. Open your arms 90 degrees to your sides.
- Without moving your neck and your lower limb look to the right as much as you can without forcing your spine.
- Go back to the starting position.
- Without moving your neck and your lower limb look to the left as much as you can without forcing your spine.
- Alternate left and right for 30 seconds.



8) Forward bend. (30 seconds)

- Starting position: Stand still. Hold your head still. Without pushing your head to the back, tuck your chin inward a little.
- Touch your chest with your chin. Bend down and try to reach your toes with your fingers without bending your knees. Note: don't force yourself to reach your just bend as much as you can.
- Go back to the starting position.
- Repeat for 30 seconds.



9) Cat-cow. (1 minute)

- Starting position: get on your hands and knees in a crawling position with your back straight.
- Cat: without moving your chest push your hip toward the floor and look up as much as possible by pushing your head up.
- Cow: from the cat position perform the opposite movement by tucking your stomach and your head in.
- Alternate slowly for one minute.



Core Stabilization Exercises

This is your main workout session. We divided it into three stages according to your treatment plan.

These exercises are designed to improve your core stabilization, increase your muscles strength and decrease the pressure on your lower back. You should perform each exercise 10 times, rest for 10 seconds then repeat again, rest for 10 seconds then repeat again (10 repetitions, 10 seconds rest intervals, 3 sets). The workout session should last 25 minutes in total.

It is very important that you stick with the exercises timetable without jumping to the next stage before the completion of the prior stage.

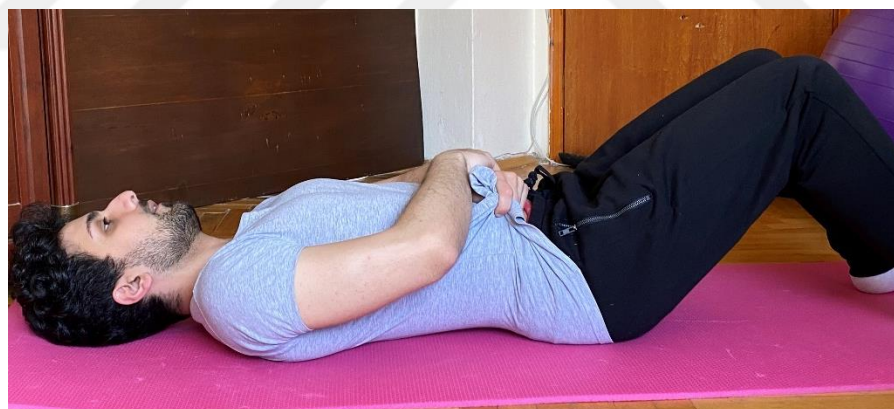
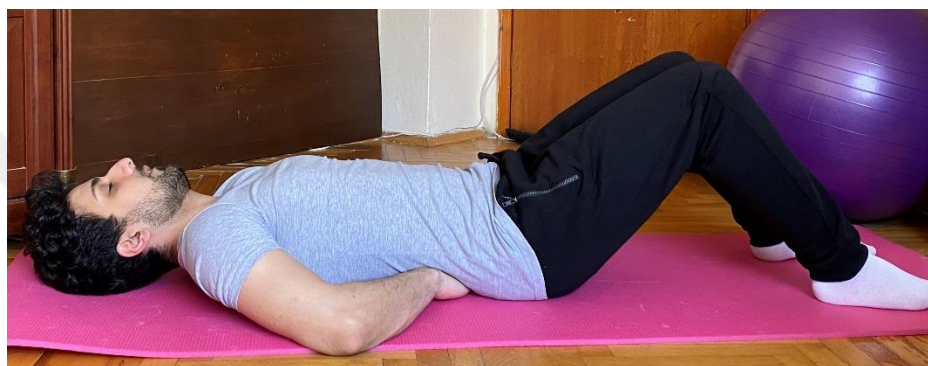
Please follow the instructions carefully and correctly!

The exercises must be done slowly, correctly, and in a controlled manner.

Stage1: perform each exercise as it is mentioned above (10 repetitions, 10 seconds rest intervals, 3 sets). This is your level 1 stage. You should do these exercises twice a week with at least one day interval between treatment days for 4 consecutive weeks.

1) Tabletop with single knee and hip flexion. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- Without losing your neutral, bend your right hip 90 degrees up as if you are placing your heel on a coffee table.



- Slowly go back to the starting position.



- Without losing your neutral bend your left hip 90 degrees up as if you are placing your heel on a coffee table.



- Slowly go back to the starting position.
- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.

- Rest for 10 seconds then move to the next exercise.
 - The total duration of this exercise should be around 4 minutes.
- 2) 4-point kneeling with single leg stretch. (4 minutes)
- Starting position: get on both hands and knees with your lower back in neutral (if you don't find your neutral, slightly squeeze your abdominal muscles without moving your spine)



- Slowly push your right leg out until your knee is fully extended without lifting your foot of the ground.



- Slowly go back to the starting position.
- Repeat with your left leg.



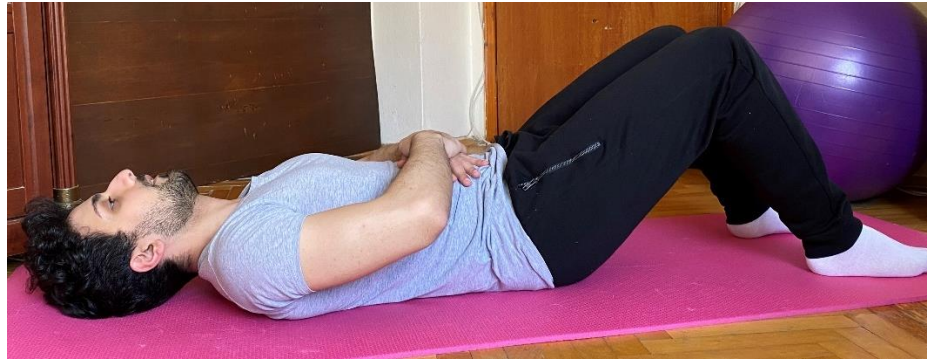
- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

3) Bridge. (5 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- First push your lower back to touch the floor, then push your hip up as much as you can. It is very important to perform this exercise slowly and controlled. Note! first your hip will be off the ground then your lower back.



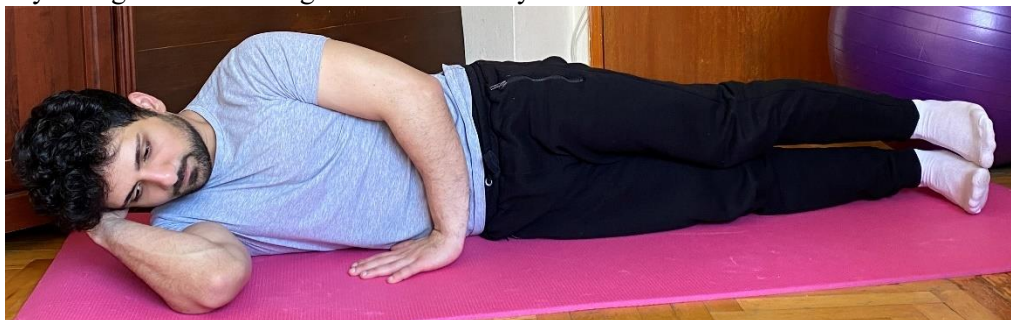
- Slowly go back to the starting position.
 - Repeat 10 times.
 - Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
 - Rest for 10 seconds then move to the next exercise.
 - The total duration of this exercise should be around 5 minutes.
- 4) One leg stretch. (4 minutes)
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
 - Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- Push your right heel until your knee is fully extended without lifting your heel off the ground.



- Slowly go back to the starting position.
 - Repeat with your left leg.
 - Alternate left and right. The total number of repetitions will be 20 (10 for each side)
 - Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
 - Rest for 10 seconds then move to the next exercise.
 - The total duration of this exercise should be around 4 minutes.
- 5) Straight leg side lifts. (4 minutes)
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
 - Starting position: lay on your left side you can lock yourself in the position by placing yourself with your right hand on the ground in front of your chest.



- Raise your right leg up as high as you can without moving your body.



- Slowly go back to the starting position.
- Repeat 10 times.
- Flip to your right side and repeat with your left leg.



- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

- 6) Sit-ups with lumbar region fixed on the floor. (4 minutes)
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
 - Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back) place your right hand on your right thigh, and your left hand on your left thigh.



- Reach the beginning of your knees with your fingers by squeezing your abdominal muscles. Your lower back will not get off the ground.

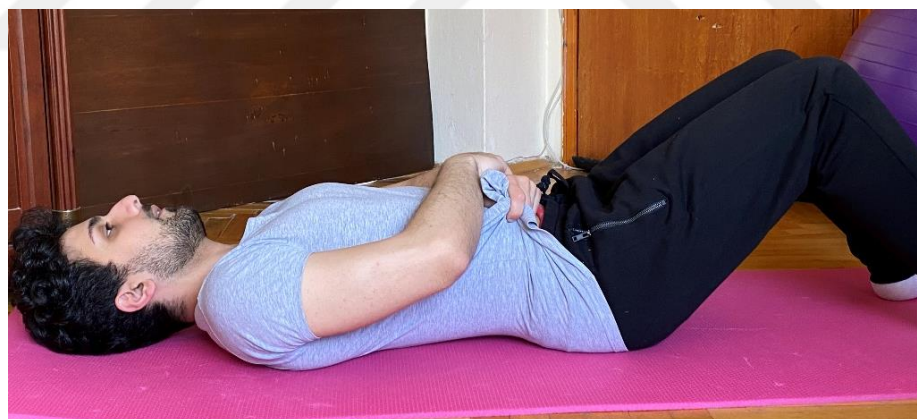
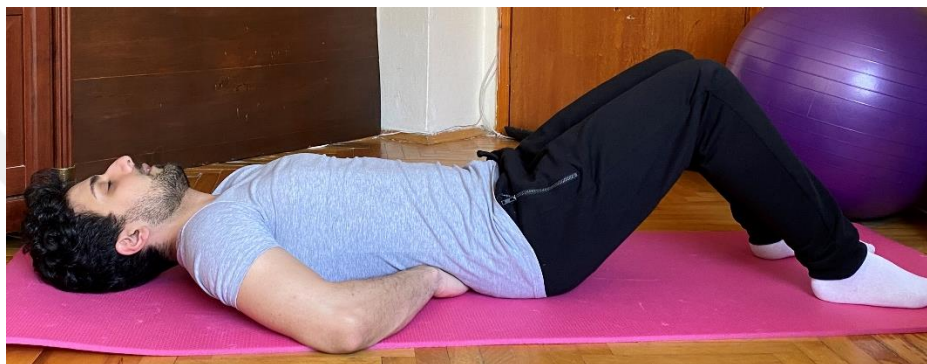


- Slowly go back to the starting position.
- Repeat for 10 times.
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the cooldown part.
- The total duration of this exercise should be around 4 minutes.

Stage2: perform each exercise as it is mentioned above (10 repetitions, 10 seconds rest intervals, 3 sets). This is your level 2 stage. You should do these exercises twice a week with at least one day interval between treatment days for 4 consecutive weeks.

1) Tabletop. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- Without losing your neutral, bend your right hip 90 degrees up as if you are placing your heel on a coffee table.



- Hold your leg in that position.
- Without losing your neutral, bend your left hip 90 degrees up as if you are placing your heel on a coffee table.



- Slowly go back to the starting position, by lowering your right hip first, then your left hip.



- The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

2) 4-point kneeling. (4 minutes)

- Starting position: get on both hands and knees with your lower back in neutral (if you don't find your neutral, slightly squeeze your abdominal muscles without moving your spine)



- Slowly push your right leg and hip out until your knee and hip is fully extended.



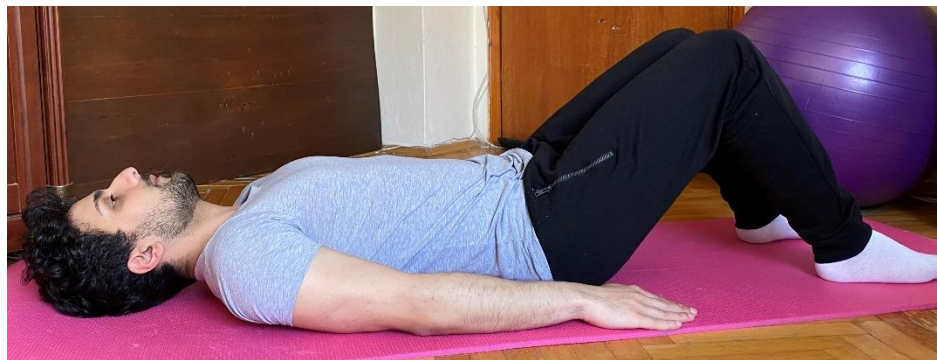
- Slowly go back to the starting position.
- Repeat with your left leg.



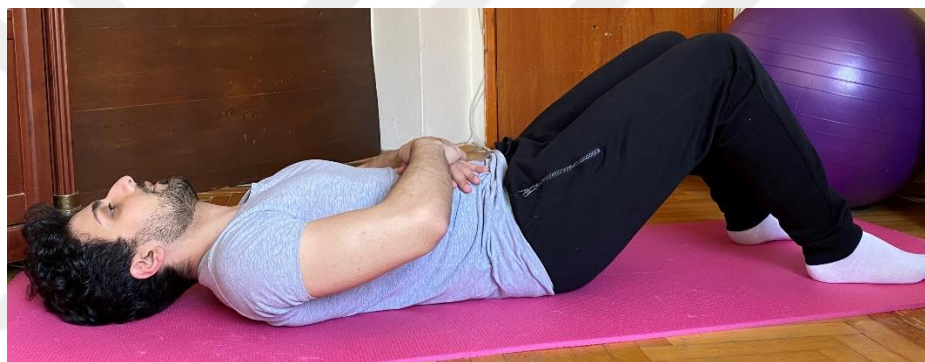
- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

3) Bridge. (5 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- First push your lower back to touch the floor, then push your hip up as much as you can. It is very important to perform this exercise slowly and controlled. Note! first your hip will be off the ground then your lower back.



- From that position, extended your right knee without moving your hip (your knees will always be parallel to each other).



- Slowly bring your right leg back and repeat with your left knee.





- Slowly go back to the starting position.



- Repeat 10 times.
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 5 minutes.

4) One leg stretch. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- First bring your right hip toward 90 degrees flexion, then fully extended your knee by pushing your leg parallel to your other knee. Your heel will be flexed throughout the movement.





- Slowly go back to the starting position.



- Repeat with your left leg.

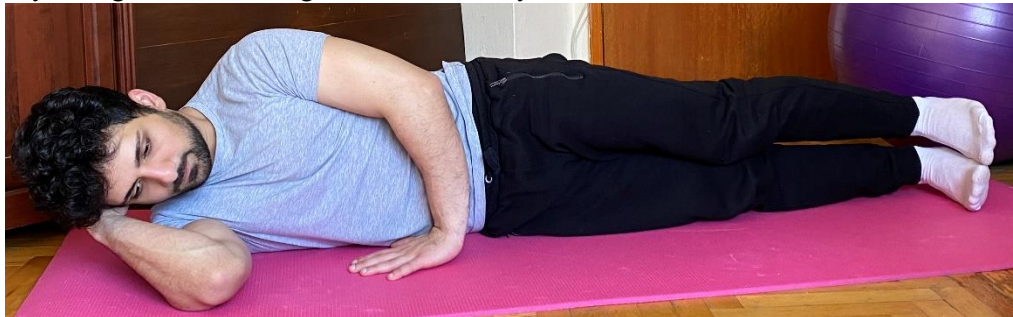




- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

5) Straight leg side lifts. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: lay on your left side you can lock yourself in the position by placing yourself with your right hand on the ground in front of your chest.



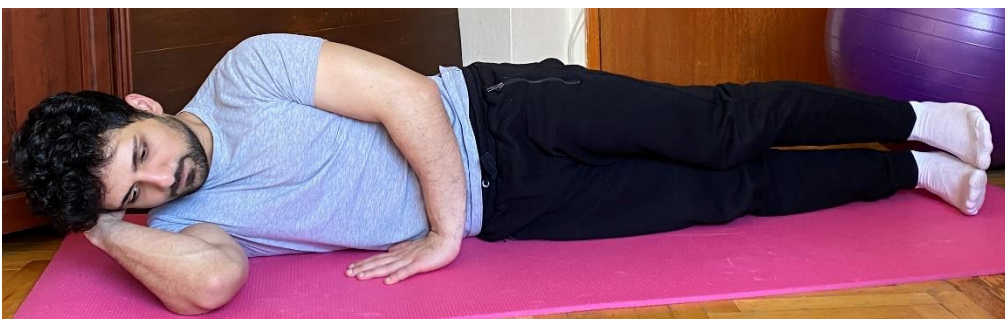
- Raise your right leg up as high as you can without moving your body.



- Hold your right leg in that position and lift your left leg slightly.



- Slowly go back to the starting position.



- Repeat 10 times.
- Flip to your right side and repeat with your left leg abducting and your right leg adducting.



- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

6) Sit-ups. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back) place your right hand on your right thigh, and your left hand on your left thigh.



- Reach your knees with the end part of your palms by squeezing your abdominal muscles. Your lower back will get off the ground.



- Slowly go back to the starting position.
- Repeat for 10 times.
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the cooldown part.
- The total duration of this exercise should be around 4 minutes.

Stage3: perform each exercise as it is mentioned above (10 repetitions, 10 seconds rest intervals, 3 sets). This is your final stage. You should do these exercises twice a week with at least one day interval between treatment days for 4 consecutive weeks.

1) Tabletop. (4 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knees 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- Without losing your neutral, bend both of your hips 90 degrees up as if you are placing your heel on a coffee table.



- Slowly go back to the starting position, by lowering your right hip first, then your left hip.
- The total number of repetitions will be 10.
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

2) 4-point kneeling. (4 minutes)

- Starting position: get on both hands and knees with your lower back in neutral (if you don't find your neutral, slightly squeeze your abdominal muscles without moving your spine)



- Slowly push your right leg and hip out until your knee and hip is fully extended. At the same time, rise your left arm until parallel to your head.



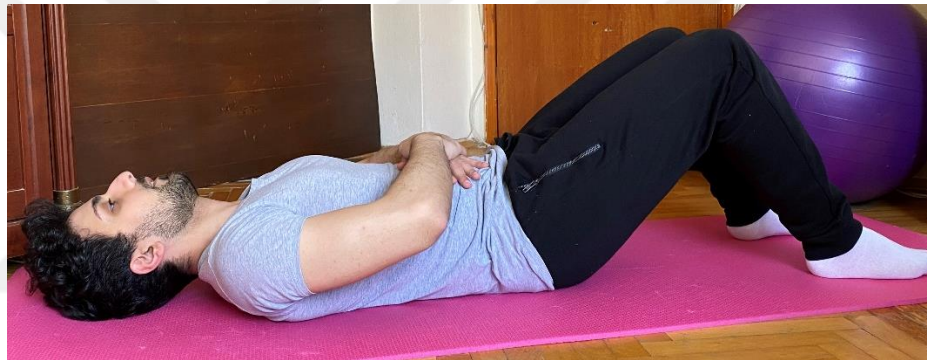
- Slowly go back to the starting position.
- Repeat with your left leg and right arm.
- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 4 minutes.

3) Bridge. (6 minutes)

- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- First push your lower back to touch the floor, then push your hip up as much as you can. It is very important to perform this exercise slowly and controlled. Note! first your hip will be off the ground then your lower back.



- From that position, extended your right knee without moving your hip (your knees will always be parallel to each other). Hold for 5 seconds.



- Slowly bring your right leg back and repeat with your left leg.



- Slowly go back to the starting position.



- Repeat 10 times.
 - Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
 - Rest for 10 seconds then move to the next exercise.
 - The total duration of this exercise should be around 6 minutes.
- 4) One leg stretch. (3 minutes)
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
 - Starting position: laydown on your back, bend your knees and hips 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back)



- Fully extended your right knee with minimum movement from your hip. Your heel will be flexed throughout the movement.



- Slowly go back to the starting position.



- Repeat with your left leg.



- Alternate left and right. The total number of repetitions will be 20 (10 for each side)
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the next exercise.
- The total duration of this exercise should be around 3 minutes.

5) Straight leg side lifts. (4 minutes)

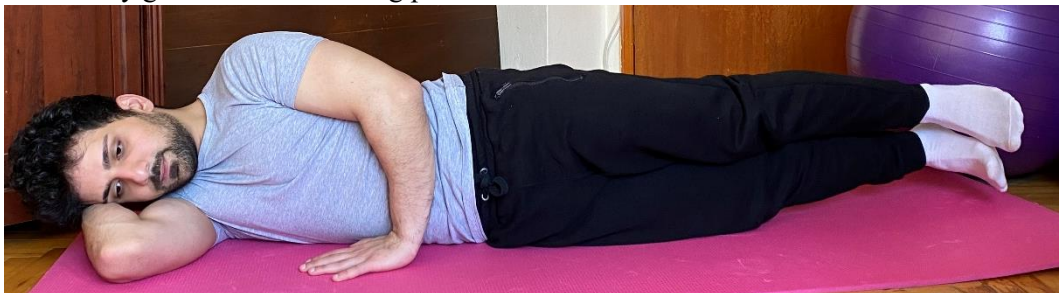
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
- Starting position: lay on your left side you can lock yourself in the position by placing yourself with your right hand on the ground in front of your chest. Lift your left leg slightly off the ground and hold it throughout the exercise.



- Raise your right leg up as high as you can without moving your body.



- Slowly go back to the starting position.

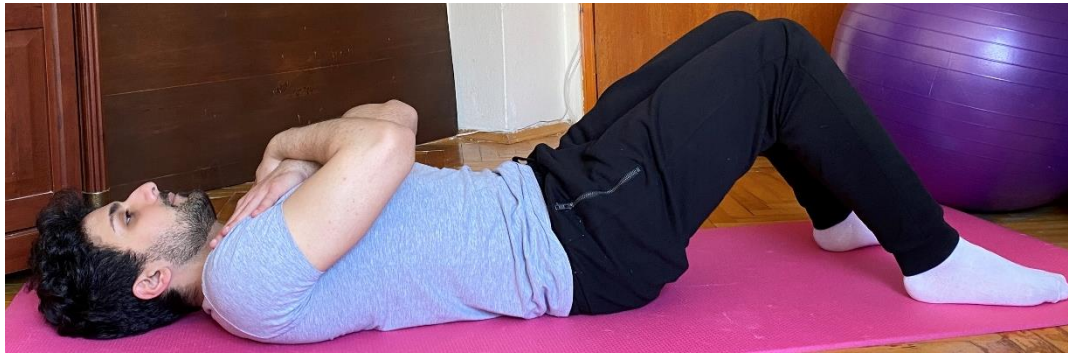


- Repeat 10 times.

- Flip to your right side and repeat with your left leg abducting and your right leg adducting.



- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
 - Rest for 10 seconds then move to the next exercise.
 - The total duration of this exercise should be around 4 minutes.
- 6) Sit-ups. (4 minutes)
- Laydown on a slightly soft surface. Ideally you should have a yoga matt, if you do not have one, a carpet or a blanket should be just fine.
 - Starting position: laydown on your back, bend your knee 90 degrees. Hold your lower back in a neutral position (your lower back must be slightly above the ground; you can place your fingers under your lower back then remove them without moving your lower back). Cross both of your arms in front of your chest.



- Reach your knees with your elbows by squeezing your abdominal muscles. Your lower back will get off the ground.



- Slowly go back to the starting position.
- Repeat for 10 times.
- Rest for 10 seconds. Repeat the exercise. Rest for 10 seconds. Repeat the exercise.
- Rest for 10 seconds then move to the cooldown part.
- The total duration of this exercise should be around 4 minutes.



Stretching and cool-down

This is the last part of your treatment session. These exercises will help your muscles to relax and stretch. Consequently, your recovery will occur in a shorter period, and they will help to restore your muscles to normal length which will allow normal load distribution over your lower back region.

It is normal to feel a little bit of discomfort in the targeted muscles. However, to not over stretch your muscles don't try to push over your limits, reach the maximum point and hold.

The cooldown will last about 21 minutes. Hold 30 seconds for each exercise, complete all the exercises then repeat them twice more. The total duration for each exercise will be 90 seconds.

Throughout the exercises, take deep breath from your nose and slowly exhale from your mouth.

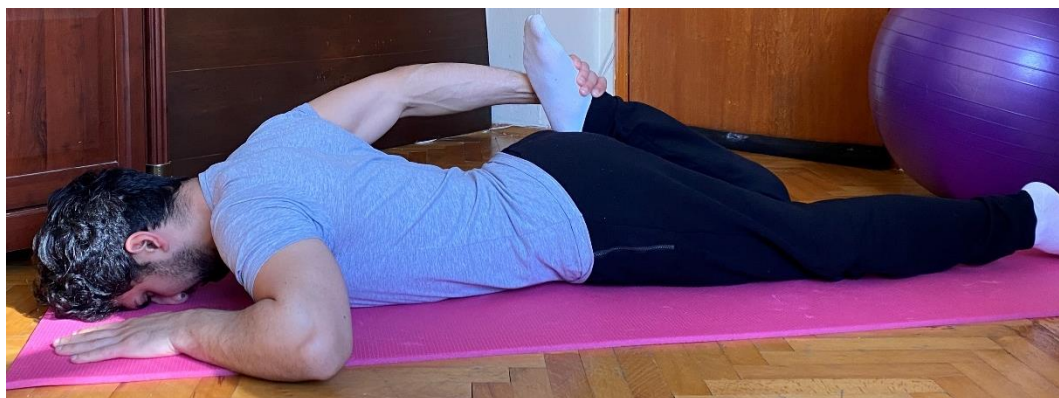
Please follow the instructions carefully and correctly!

The exercises must be done slowly, correctly, and in a controlled manner.

1- Quadriceps stretch.

- Lay on your stomach.
- Bend your right leg toward your buttocks. Hold for 30 seconds. Rest it.
- Repeat with your right leg.





2- Kneeling hip flexor stretch.

- Sit on one knee, place the other leg one step in front of you.
- Slowly push yourself forward and hold for 30 seconds.
- You will feel the stretch in your passive thigh.
- repeat but change your legs' positions.





3- Sitting adductor stretch.

- Sit on your buttocks and hold your legs to your chest.
- Let your legs drop to the floor.
- Lock yourself by holding your feet.
- Push your hips toward the ground as much as possible and hold for 30 seconds.



4- Seated hip and ITB stretch.

- Sit in a long sitting position and cross your right leg in front of you.



- Place your left arm slightly under your right knee.



- Place your right hand directly behind you to lock your self in the position.
- Look to your right, at the same time slightly push your right leg with your left arm.



- Hold for 30 seconds.
- Repeat with the other leg and arm, this time you will look to your left side.



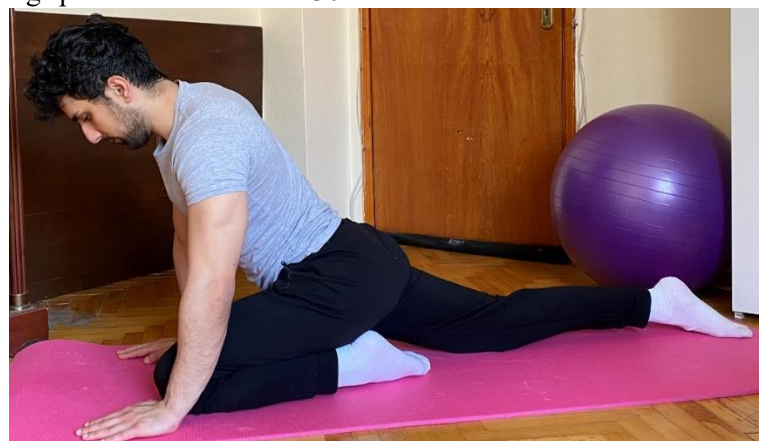
- 5- Gluteal stretch (in prone position).
- Sit on your legs.



- Push your left leg behind you as much as you can.



- Get closer to the ground and hold for 30 seconds.
- Change your legs position and hold for 30 seconds.



6- Piriformis stretch:

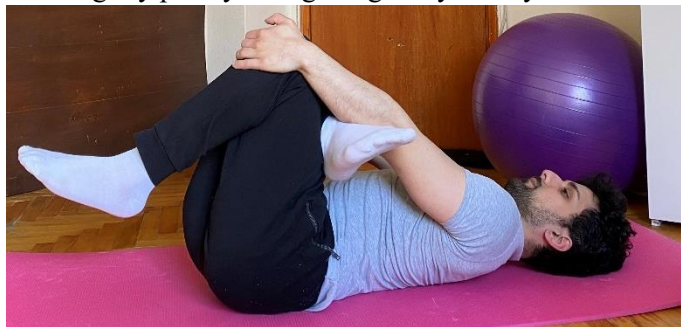
- Lay on your back.



- Cross your right leg slightly above your left leg.



- Bend your left leg, with your left hand's help bring your left leg as close as possible toward you, at the same time slightly push your right leg away from you.



- Hold for 30 seconds.
- Change your legs position and hold for 30 seconds.





7- Hamstring-gastro stretch with a band.

- Grab a band, towel or scarf with both of your hands.
- Sit in a long sitting position.
- Place the band on and slightly under your right toes.



- Without bending your knee lay back and bring your right leg as high as you can without bending your knee.



- Hold for 30 seconds then repeat with your left leg.



8- Abdominal stretch.

- Lay on your stomach.
- Place your hand close to you and parallel to your nipple line.
- Keep your stomach close to the ground as much as possible, look and push yourself up.





- Hold for 30 seconds.
- 9- Bend forward stretch.
- Standup.
- Slowly look down and bend your back forward.



- As much as possible get your fingers close to your toes without bending your knees.



- Hold for 30 seconds.

Congratulations, you have finished your treatment session for today! Remember to keep your lower back straight and to sit the right way.

See you at the end of your treatment plan.

Best regards.

APPENDIX 10. COMPLIANCE TIMETABLE

This table will help you to maintain your progress and indicates your compliance to your treatment plan.

Please write the date in which you performed the exercises.

Best regards.

Name Surname:

Week	Fist Session	Second Session
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

APPENDIX 11. CURRICULUM VITAE

Personal Information

Name	Rayan	Surname	Ahmed Tawfek
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Education

Degree	Department	The name of the Institution Graduated From	Graduation year
Master	Physiotherapy and Rehabilitation	Yeditepe University	2023
University	Physiotherapy and Rehabilitation	Eastern Mediterranean University	2019
High school	Science	Alridhwan High School	2014

Languages	Grades (#)
Arabic	Native
Turkish	B2
ENGLISH	6.5 IELTS

All the grades must be listed if there is more than one (KPDS, ÜDS, TOEFL; EELTS vs),

Work Experience (Sort from present to past)

Position	Chapter 2 Institute	Duration (Year - Year)
Physiotherapist Assistant	Saudi German Hospital (Saudi Arabia)	1

Computer Skills

Program	Level
Word	Good
PowerPoint	Good

*Excellent , good, average or basic

Others (Projects / Certificates / Rewards)

Certified Clinical Pilates Instructor
Certified Orthopedic Manual Therapy Practitioner
Certified Dry Needling Practitioner