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THORACIC MOBILITY VERSUS HIP MOBILITY EXERCISES TO CORE STABILIZATION IN LUMBAR SPONDYLITIS

BY
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CHAPTER I
INTRODUCTION

Low back pain (LBP) is one of the most prevalent musculoskeletal conditions and a leading cause of disability across all age groups **(Cieza et al., 2021; Ferreira et al., 2023).** LBP can be classified as acute (lasting less than 6 weeks), subacute (6–12 weeks), or chronic (more than 12 weeks) **(Foster et al., 2021).** Lumbar spondylosis is a degenerative spinal disorder that primarily affects the lower back. It involves age-related changes such as intervertebral disc degeneration, facet joint osteoarthritis, and osteophytes formation **(Ravindra et al., 2020; Jensen et al., 2021; Skundric et al., 2021).** The incidence and prevalence of lumbar spondylosis increases with age. Radiographic evidence of spondylosis is present in more than 95% of individuals over the age of 65 **(Jensen et al., 2021).** Clinical manifestations often include chronic low back pain, stiffness, reduced spinal mobility **(Schmidt et al., 2020; Adams et al., 2021; Skundric et al., 2021).** Lumbar spondylosis can significantly impair daily function and quality of life. It also contributes to increased healthcare costs, absenteeism from work, reduced productivity and greater demands on health care systems **(Ravindra et al., 2020; Skundric et al., 2021; Chen et al., 2022).**

The clinical manifestations of lumbar spondylosis generally consist of chronic low back pain, stiffness, and limited range of motion of the spine, that severely impact a patient's ability to carry out daily function and their overall quality of life **(Schmidt et al., 2020; Adams et al., 2021; Skundric et al., 2021).** These clinical manifestations result in greater healthcare costs, absenteeism from work and diminished productivity, and increased pressure on the healthcare system **(Ravindra et al., 2020; Skundric et al., 2021; Chen et al., 2022).**

Treatments for lumbar spondylosis may involve pharmacological therapy, physiotherapy, or surgical interventions depending on severity and patient response **(Foster et al., 2021; Skundric et al., 2021; Lin et al., 2022;).** Conventional physiotherapy for lumbar spondylosis typically includes modalities such as heat, electrical stimulation, stretching, and core strengthening **(George et al., 2020)**. A growing body of evidence supports a more holistic approach that incorporates multi-regional mobility training to address the root causes of dysfunctional movement **(Page et al., 2020; Skundric et al., 2021).**

Exercise therapy, particularly core stabilization training, is an important intervention for patients with low back pain because it focuses on activating the deep stabilizing muscles of the trunk (e.g., transversus abdominis and multifidus), which are valuable for segmental control of the spine **(Saragiotto et al., 2020)**. By focusing on strengthening these muscles, exercise therapy increases spinal stability, reduces mechanical loading, and improves postural control **(Hodges et**

al., 2020; García-López et al., 2023). The evidence supporting this intervention is abundant; core stabilization training has demonstrated significant reductions in pain intensity, improvement in functional outcomes, and reduction in the risk of recurrence in people with lumbar spondylosis **(Liu et al., 2019; Park & Kim, 2020)**. For instance, the meta-analysis conducted by **Liu et al. (2019)** showed effective use of progressive core activation programs in pain and disability scores compared to usual care. Additionally, the research by **García-López et al. (2023)** demonstrated that trunk stabilization training caused significantly decreased pain and disability as well as positively altered trunk muscle activation, demonstrating its core value in restoring functional movement, while managing chronic symptoms.

Recently, the importance of thoracic spine and hip mobility exercises have been highlighted in treatment of patients with chronic low back pain **(Sueki et al., 2013; Wainner et al., 2021).** Limitation of thoracic spine and hip mobility has been associated with altered load distribution and increased mechanical stress on the lumbar vertebrae **(Liebenson et al., 2020; Rose et al., 2020; Schmidt et al., 2020).** This suggests that interventions addressing only the lumbar region may be insufficient in restoring functional movement patterns and alleviating symptoms in the long term **(McGill, 2016).**

The thoracic spine contributes significantly to global spinal mobility, especially in rotation and extension **(Johnson et al., 2012; Bordoni & Zanier, 2021).** Improving thoracic spine mobility has shown promising effects on reducing low back pain, enhancing dynamic trunk control and optimizing breathing patterns **(Cook et al., 2020; Kumar & Singh, 2021; Chen et al., 2022).**

The hip joint provides essential mobility and stability during walking, squatting, and lifting. In individuals with lumbar spondylosis, limited hip mobility; particularly in extension and internal rotation, is often observed. This restriction leads to compensatory lumbar hyperextension or rotation, contributing to increased mechanical strain on the lumbar spine **(Lewis et al., 2017; Thompson et al., 2021)**. Mobility exercises that restore hip joint range, reduce muscle tightness and improve pelvic control can positively influence lumbar biomechanics and reduce pain perception **(Wilson & Clarke, 2023; Martinez-Calderon et al., 2020).**

While previous research has indicated strong effectiveness of core stabilization, thoracic mobility, and hip mobility exercises focused on lumbar conditions, the specific associated benefits of adding these interventions compared one-to-one has not been examined; generally, we observe a void in two specific comparative studies of the two combined approaches (adding thoracic mobility exercises to core stabilization and adding hip mobility exercises to core stability) with lumbar spondylosis treatment **(Radwan et al., 2024; Skundric et al., 2024)**. Therefore, it is not known if treating stiffness in the thoracic region, or restrictions in the hip joint, combined with a core stability program, produces more favorable outcomes in terms of pain relief, functional improvements, and biomechanical changes with regard to lumbar spondylosis. According to author knowledge there is lack of researches that compare between addition of thoracic mobility and hip mobility exercises to core stabilization .So this study seeks to fill this gap by comparing which approach to adjunctive treatment is more effective for lumbar spondylosis specifically.

Statement of the Problem

Which modality is superior when combined with core stabilization for treating individuals with lumbar spondylosis in terms of outcomes: thoracic mobility exercises or hip mobility exercises with regard to severity of pain, disability function, range of motion at the lumbar spine (flexion, extension, lateral flexion, and rotation), spinal mobility, quality of life, and fear of movement?

Purpose of the Study

This study is conducted to determine the effect of addition of thoracic mobility versus hip mobility exercises to core stabilization on pain severity (NPRS-Ar), functional disability (MODI-Ar), lumbar range of motion (BROM), spinal mobility (modified schober test), quality of life (SF-36-Ar) and fear of movement (Tampa-Ar) in treatment of patients with lumbar spondylosis.

Significance of the Study

Lumbar spondylosis is a prevalent degenerative condition affecting 27.2% to 37% of the adult population, with incidence increasing to 80% in individuals over age 40 **(Skundric et al., 2021).** The condition represents a significant contributor to functional disability and healthcare utilization globally **(Ravindra et al., 2020).**

The research explores the principle of regional interdependence by examining thoracic spine and hip mobility contributions to lumbar function **(Kose et al., 2023; Radwan et al., 2024).** Thoracic mobility restrictions may lead to compensatory lumbar hypermobility and increased mechanical stress on lumbar segments **(Radwan et al., 2024; Skundric et al., 2021).** Limited hip mobility, particularly in extension and internal rotation, alters lumbopelvic rhythm and increases lumbar spine stress during functional activities **(Radwan et al., 2024).**

Recent studies about thoracic mobility have shown a specific relationship that exists between improving thoracic function and improving low back pain. According to **Park and Lee (2024),** patients who participated in thoracic mobility exercise showed greater reductions in pain, greater proprioception and static balance than the group treated with stabilization exercises for low back pain.

Salah Eldeen et al. (2024) reported that adding thoracic spine mobilization, to usual physical therapy, had significantly lowered pain levels and better lumbar function in patients with chronic lumbosacral radiculopathy. Additionally, **Kostadinović et al. (2020)** reported grater reductions in pain and disability with with closed-chain thoracic mobilization.

Recent studies about hip mobility have shown that addressing limitations in the hips is just as important. **Kim et al. (2021)** reported that improving hip hyperextension reduced the amount of compensatory pelvic tilt in patients with chronic low back pain. **Ferraresi et al. (2022)** reported that improving hip flexor flexibility and strength of the gluteal muscles could reduce mechanical overload on low back pain. **Ceballos-Laita et al. (2023)** reported significant short-term improvements in pain and function with addition of hip-based treatment modalities.

By targeting restrictions beyond the lumbar spine, this integrated approach may enhance outcomes in term of pain severity, functional disability, lumbar range of motion, spinal mobility, quality of life, and fear of movement in patients with lumbar spondylosis. The current study may provide a more conclusive insight in treatment of patients with lumbar spondylosis.

Delimitation

This study will be delimited to:

Patients: 60 patients diagnosed with lumbar spondylosis with age range from 40 to 60 years **(Hodges et al., 2020).**

Assessment outcomes: Pain levels in participants were assessed using the Numerical Pain Rating Scale (NPRS-Ar). Functional disability was assessed using the Modified Oswestry Disability Index (MODI-Ar), Lumbar Range of Motion was evaluated using a Back Range of Motion (BROM) device, spinal mobility was assessed with the Modified Schober's test, Health-Related Quality of Life was assessed with the Short Form 36 Health Survey (SF-36-Ar) and fear of movement was assessed using the Tampa scale for Kinesiophobia (Tampa-Ar).

Treatment procedures:

- **Group A (Control Group):** A program of core stabilization exercises including flexibility and strength of core muscle (multifidus and pelvic floor muscles).
- **Group B (First Experimental Group):** A program of core stabilization exercises combined with a program of thoracic mobility exercises including flexibility exercises in all directions of thoracic spine flexion, extension, lateral flexion, and rotation.

- **Group C (Second Experimental Group):** A program of core stabilization exercises combined with a program of hip mobility exercises including flexibility exercises for extensor and internal rotators muscle groups.

Basic Assumptions

- Participants will follow our instructions during assessment and treatment procedures
- They will refrain from additional physiotherapy during the study period.

Hypotheses

1. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **pain severity** in participants with lumbar spondylosis.
2. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **functional disability** in participants with lumbar spondylosis.
3. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar flexion range of motion** in participants with lumbar spondylosis.
4. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar extension range of motion** in participants with lumbar spondylosis.
5. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar right lateral flexion range of motion** in participants with lumbar spondylosis.
6. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar left lateral flexion range of motion** in participants with lumbar spondylosis.
7. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar right rotation range of motion** in participants with lumbar spondylosis.
8. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **lumbar left rotation range of motion** in participants with lumbar spondylosis.

9. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **spinal mobility** in participants with lumbar spondylosis.
10. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **quality of life** in participants with lumbar spondylosis.
11. There will be no significant difference between core stabilization, core stabilization with thoracic mobility exercises, and core stabilization with hip mobility exercises on **fear of movement** in participants with lumbar spondylosis.

CHAPTER II
LITERATEARE REVIEW

Anatomical and Functional Foundations of the Lumbar Spine

The lumbar spine is a complex mechanical structure that aims to stabilize, allow movement, and transmit loads from the upper body to the pelvis. The lumbar spine typically comprises five vertebrae (L1 - L5), the largest of the mobile vertebrae, reflecting its primary function is weight-bearing **(Adams et al., 2021)**. Each lumbar vertebra has a vertebral body in the anterior portion that is designed to resist compressive loads, and a posterior vertebral arch that forms the vertebral foramen which creates a canal for the cauda equina, nerve roots traveling down to the sacrum. Important functionally are the intervertebral joints and the facet (zygapophyseal) joints. Intervertebral discs consist of a central gelatinous structure called a nucleus pulposus that is surrounded by a tough, laminated structure called an annulus fibrosus, which provides shock absorption, as well as motion between vertebral bodies. Degeneration of the intervertebral discs is a hallmark of lumbar spondylosis, with the degeneration often including desiccation and decreased disc height **(Battié et al., 2014; Ravindra et al., 2020).** The paired facet joints are synovial joints created by the inferior and superior articular processes of adjacent vertebrae and play a substantial part providing direction, as well as the limits to the range of motion of the spine, particularly if rotating or extending the spine. Osteoarthritis of these joints is another hallmark of the spondylotic process **(Ravindra et al., 2020).**

The “core” musculature regulates the stability and dynamic control of this structure. Often speaking of this system in layers, we can speak of the deep local stabilizers (e.g., lumbar multifidus, transversus abdominis), which create segmental stability and proprioceptive information, and the global movers (e.g., rectus abdominis, erector spinae), which create gross trunk movement **(Hodges et al., 2020)**. Proper coordination of these muscles is important for maintaining neutral spine position, distributing mechanical loads, and preventing excessive stress on passive structures. There is clear evidence that dysfunction of the deep stabilizers is a common risk factor for the onset and persistence of chronic nonspecific LB problems **(Saragiotto et al., 2020)**. As a result, a core stabilization exercise aims to restore this muscle coordination in order to improve spinal stability, unload the spine, and improve postural control **(García-López et al., 2023)**.

Lumbar Spondylosis: Pain, Function, and Quality of Life

Lumbar spondylosis refers to a degenerative disease process in the lower spine, which may involve intervertebral disc desiccation, osteophyte formation, and facet joint arthropathy **(Ravindra et al., 2020)**. The pathophysiological process of lumbar spondylosis is the gradual mechanical suboptimal processes which may develop overtime in lumbar discs and joints **(Battié et al., 2014; Adams et al., 2021)**. Clinically, the individual may experience chronic low back pain, stiffness, and loss of motion in the spine **(Schmidt et al., 2020; Adams et al., 2021)**. These clinical consequences result in increased cost to healthcare, time lost from work, reduced productivity, and increased demands on the healthcare system **(Ravindra et al., 2020; Chen et al., 2022)**.

Evaluation of the patient with lumbar spondylosis should be multidimensional to accurately assess the problems associated with the disease process. A provider would assess pain severity, functional disability, range of motion of the lumbar spine, and measures of health-related quality of life **(Schmidt et al., 2020)**. Pain levels are an important, legitimate outcome that is usually assessed by a unidimensional scale such as the Numerical Pain Rating Scale (NPRS) which is a well-studied, popular 11-point scale with good test-retest reliability ($r = 0.95$ to 0.96) and clinical applicability **(Ferraz et al., 1990; Alghadir et al., 2018).**

Functional disability, specifically related to low back pain, can be accurately assessed using disease-specific questionnaires. The Modified Oswestry Disability Index (MODI) is one of the questionnaires to assess functional disabilities related to self-care, lifting, walking, and sitting. The MODI is comprised of 10 items. The MODI has excellent internal consistency ($\alpha = 0.94$), and test-retest reliability (ICC = 0.91), making it a valid measure in this patient population **(Fairbank & Pynsent, 2000; Alnahdi, 2025)**.

Lastly, given that lumbar spondylosis has a significant effect on daily function and overall quality of life **(Skundric et al., 2021)**, it is also important to assess health related quality of life (HRQoL). The Short Form 36 Health Survey (SF-36) is a general HRQoL measure that covers 8 domains including physical functioning, pain, and mental health. Together, the SF-36 offers a more complete picture of the patient's health status that is not defined purely on physical impairment **(Ware & Sherbourne, 1992)**.

Instrumentation for Objective and Subjective Assessment

This research will utilize a range of validated measures to represent the multidimensional nature of lumbar spondylosis. The patient-reported nature of the pain, disability, quality of life, and fear of movement experience will be measured employing the Arabic versions of the Numeric Pain Rating Scale (NPRS-Ar), the Modified Oswestry Disability Index (MODI-Ar), the Medical Outcomes Study 36-Item Short Form Survey (SF-36-Ar), and the Tampa Scale for Kinesiophobia (Tampa-Ar), respectively, **(El-Kalla, 2016; Alghadir et al., 2018; Al-Shudifat et al., 2020; Alnahdi, 2025)**.

The objective physical measurements will consist of lumbar Range of Motion (ROM), and spinal mobility. The Back Range of Motion (BROM) device is a dual inclinometer system dependent upon gravity to measure spinal ROM in the sagittal and frontal planes while preventing pelvic compensation. The BROM device has established inter-rater reliability ratings of ICC = 0.92-0.96, as well as concurrent validity against radiographic measurements of r = 0.87-0.93 **(Kumar & Singh, 2021; Chen et al., 2022)**. The Modified Schober Test will be used to assess spinal mobility and is a clinical measure of lumbar flexion that has been shown to have inter-rater reliability ICC = 0.89-0.94, and intra-rater reliability ICC = 0.92-0.96 **(Tousignant et al., 2005)**. Implementing these exact specific validated measures supports the scientific rigor and clinically meaningful outcomes of this study.

Conventional physiotherapy and low back pain

Conventional physiotherapy for LBP typically involves modalities such as heat, ultrasound, TENS, stretching, and general strengthening exercises. These methods aim to reduce pain, improve flexibility, and restore basic function. However, recent studies suggest limited long-term effectiveness when used in isolation. A recent systematic review reported that while conventional physiotherapy is beneficial in the acute phase, it may not address underlying motor control deficits or movement dysfunctions **(Hayden et al., 2021).**

Recent evidence also emphasizes the need to integrate functional movement training and psychosocial interventions into traditional physiotherapy plans to enhance outcomes in chronic LBP patients **(Kamper et al., 2015).**

Core stabilization and low back pain

Core stabilization exercises play a pivotal part in the management of low back pain, as these exercise prescriptions focus on the deep trunk muscles, specifically transversus abdominis and multifidus, which are vital for achieving the spinal segmental control. Evidence clearly supports that dysfunction in these deep stabilizers is one important factor most associated with the onset and persistence of chronic LBP **(Saragiotto et al., 2020)**. Therefore, the goal of core stabilization exercise is to restore that muscle coordination to improve spinal stability, minimize mechanical stress, and improve postural control to address symptoms, and of course prevent recurrence.
This targeted approach has strong support from a wealth of evidence. Systematic reviews and meta-analysis demonstrate that core stability and motor control

training achieve better outcomes in reducing pain and improving function compared to general exercise or usual care **(Shamsi et al., 2019; Wang et al., 2020; Yamato et al., 2021)**. High-quality randomized controlled trials back this up. For example, **García-López et al. (2023)** found a statistically significantly greater reduction in pain and disability, and positive changes in trunk muscle activation patterns associated with primary outcomes of core stabilization compared to standard physiotherapy. A meta-analysis by **Liu et al. (2019)** across 15 RCTs found progressive core stabilization programs provided clinically important decreases in pain intensity and symptom severity scores. The benefits can be observed on a structural basis, with **Park and Kim's (2020)** manuscript demonstrating real-time ultrasound guidance resulted in improved deep muscle thickness, which was positively associated with functional outcomes.

The benefits of core stabilization are not limited to musculoskeletal changes, but it also impacts the central nervous system. A recent study **by Ramirez-Velez et al. (2021)** using functional MRI demonstrated that a 12-week core stabilization program led to neuroplasticity, as seen by increased cortical thickness in associated sensorimotor areas of the brain and connectivity in the brain. These neurological changes help explain the sustained patient reported and clinically significant improvements while also suggesting that core training may not just create more muscular strength but also affect how the brain processes pain and motor control. Thus, the literature supports that core stabilization is a multidimensional approach to address peripheral and central contributors to chronic low back pain.

<u>Thoracic mobility exercises and Lumbar Spondylosis: Underlying Mechanisms and Evidence</u>

Lumbar spondylosis is a degenerative condition of the spine often attributed to age-related changes in the lower back, including intervertebral disc desiccation, facet joint osteoarthritis, and osteophyte formation **(Ravindra et al., 2020)**. The consequences of these changes can frequently include chronic low back pain, stiffness, reduced spinal mobility, and secondary to that, functional disability, ultimately leading to a diminished quality of life for the patient **(Schmidt et al., 2020; Skundric et al., 2021).** The concept of regional interdependence describes the idea that dysfunction in one area of the kinetic chain may contribute to pain and disability elsewhere. In this regard, the thoracic spine has been noted to be a noteworthy contributor to lumbar pathology with respect to limited mobility. A hypomobile thoracic segment may place the lumbar spine at a physiological disadvantage of needing to compensate to achieve functional tasks through an exceeded range of motion and in turn, increased mechanical stress and compensatory hypermobility **(Liebenson et al., 2020; Radwan et al., 2024)**. It is suggested that improving mobility of the thoracic spine would restore normalized spinal biomechanical function, reducing compensation and strain in structures of the lumbar spine while alleviating symptoms of lumbar spondylosis.

The pathophysiological mechanism underlying this context involves altered loading distribution within the spinal system. The thoracic spine is anatomically and biomechanically designed to contribute significantly to global spinal rotation and extension **(Johnson et al., 2012; Bordoni & Zanier, 2021)**. When thoracic mobility is limited or restricted, there are inordinate kinematic demands during functional activities that places additional stress on lumbar segments of the spine **(Rose et al., 2020).** This motion demands the lumbar spine to enter normal ranges of motion that exceed the physiological design of the lumbar spine, especially with regards to rotation and extension. This can also lead to additional mechanical stress that contributes to intervertebral disc, facet joint and/or ligamentous injury. In an already compromised spine due to spondylosis, this forced adaptation can increase pain, accelerate structural degeneration, and result in a cycle of dysfunction and compensation with hypermobility **(McGill, 2016)**. Thus, restoring mobility at thoracic segments of the spine promotes a more normal loading distribution on the lumbar spine which in turn may alleviate pain, and restore function **(Cook et al., 2020; Kumar & Singh, 2021).**

The number of studies about thoracic mobility exercises as a treatment approach and for improving treatment outcomes in individuals with low back pain and degenerative conditions, to include spondylosis, is increasing. For example, **Sivakumar & Hossain (2025)** described a study of thoracic mobility exercise for upper back pain in young adults. Following a two-week protocol in which thoracic mobility exercises for two weeks were used in combination with breathing exercises, researchers found a reduction in pain intensity and an improvement in range of motion in thoracolumbar extension and extensor muscle strength relative to manual release therapy. These studies suggest meaningful effects of thoracic mobility exercises relative to posterior chain interventions. In a study involving middle-aged women with chronic pain **(Hwang et al., 2023)** found that, following four weeks of thoracic mobility exercises, there was an overall significant improvement in thoracic rotation range of motion, pain scores (NPRS), and disability (ODI) benefits for both pain and function.

Further supporting the comparative effectiveness of thoracic-centered exercise is research by **Park & Lee (2024)** showing that patients with non-specific chronic low-back pain had statistically greater improvements in pain, proprioception, and static balance after 6 weeks of thoracic mobility exercise (TME) compared to the lumbar stabilization group. This suggests that somatosensory motor benefits may be enhanced through TME. Interesting results were found by integrating thoracic mobilization with core stabilization. In a study by **Kostadinović et al. (2020)** with patients with chronic LBP and radiculopathy, those who underwent lumbar stabilization with closed-chain thoracic mobilization (e.g., cat-camel exercises) experienced greater reductions in pain and impairment compared to patients who underwent stabilization and open-chain thoracic exercises.

The adjunctive value of manual thoracic mobilization has also been well documented. **Salah Eldeen et al. (2024)** have shown some of the greatest pain reduction and functional improvement in chronic lumbosacral radiculopathy patients when adding thoracic spine mobilization to conventional physiotherapy. In a related study, **Rahman et al. (2023)** observed that individuals who received the multimodal treatment that included thoracic mobilization achieved greater reductions in pain and less vertebral slippage than the group receiving conventional physiotherapy for treatment of lumbar spondylolisthesis. There were also benefits for compensatory mechanisms. **Yasuda et al. (2023)** used thoracic self-mobilization in lumbar hypermobility and had significant reductions in pain, improved spinal mobility, and increased lumbar rotation angle suggesting reduced compensatory strain in the lumbar spine region.

Sung (2014) also considered the role of psychological mechanisms important in the management of chronic pain. This study demonstrated that thoracic mobilization and manipulation along with sling exercises resulted in improvements in functional disability (ODI), spinal extension ROM, and FABQ outcomes, suggesting that thoracic interventions may have an influence on fear avoidant behaviors in managing chronic low back pain.

Together this evidence provides strong support for the use of thoracic mobility exercises and mobilizations, whether applied as a stand-alone treatment or in conjunction with core stabilization, to reduce pain, improve functional capacity and spinal mobility, improve sensorimotor control and at a minimum have a positive influence on psychological outcomes in patients with low back pain, which provides a solid basis to use these interventions in the management of lumbar spondylosis.

Hip Mobility Exercises and Low Back Pain: Mechanisms and Efficacy

The reason for implementing hip mobility exercises in the treatment of low back pain is based on the idea of regional interdependence, or how dysfunction in the hip joint impacts lumbopelvic biomechanics. Because mobility is limited in the hip joint, specifically with extension and internal rotation, the normal kinematic chain is disrupted during functional movements like walking, squatting, and bending **(Vad et al., 2004; Scholtes et al., 2009)**. The restrictions inhibit normal ranges of motion in the hip and require the lumbar spine to maximize its motion and pelvic tilt, causing mechanical overload, increased stress to passive spinal structures, pain, and dysfunction **(Kim et al., 2021; Ferraresi et al., 2022).**

There is an increasing amount of evidence that supports targeting these hip restrictions. Clinical trials have shown that rehabilitation programs that emphasize hip mobility and motor control yield better outcomes in pain and function than lumbar-focused rehab alone **(Selkowitz et al., 2013)**. This is corroborated by trials demonstrating that manual therapy directed toward the hip produced greater reductions in pain and disability than lumbar-focused treatment in certain cases, which further supports the clinical reasoning of a hip-based intervention **(Geisser et al., 2005)**. There are also documented advantages of pairing hip training with core stabilization. Interventions that included hip stretching and strengthening have reportedly improved pain, balance, lumbar stability, and quality of life **(Kim & Yim, 2020).**

Systematic reviews and meta-analyses summarize this literature declaring that hip mobility and gluteal strengthening interventions remove mechanical overload on the lumbar spine **(Ferraresi et al., 2022).** Limitations of the empirical literature remain; a recent meta-analysis identified that while hip-targeted interventions offer modest short-term improvements, long-term efficacy was ambiguous and overall evidence certainty was rated as low due to methodological heterogeneity **(Ceballos-Laita et al., 2023).** Overall, these findings support hip mobility work as a useful component of a multimodal treatment strategy for low back pain as it is recognized as a key peripheral mechanism in producing lumbar dysfunction.

<u>Combined thoracic and hip mobility exercises and low back pain</u>

Choi and Kim. (2023) examined the effects of c**ombining thoracic and hip joint mobility exercises** with lumbar stability training on pain and balance in 20 adult women with chronic low back pain. Participants were divided into two groups: the experimental group received thoracic and hip mobility plus lumbar stability exercises, while the control group received lumbar stability and general exercises. The intervention lasted six weeks, with sessions held three times per week. Pain was assessed using the Visual Analog Scale (VAS), and balance was measured with Basic Therapy 4. Both groups experienced significant pain reduction; however, only the experimental group showed improvements in both static and dynamic balance, though intergroup differences were not statistically significant. Study limitations include a small, gender-specific sample and short intervention duration.

CHAPTER III
MATERIALS AND METHODES

This study will be conducted at the outpatient physical therapy clinic of the Faculty of Physical Therapy, Cairo University to investigate the effect of adding thoracic mobility versus hip mobility exercises to core stabilization on pain severity (NPRS-Ar), functional disability (MODI-Ar), lumbar range of motion (BROM), spinal mobility (modified schober test), quality of life (SF-36-Ar) and fear of movement (Tampa-Ar) in treatment of patients with lumbar spondylosis.

Design of the study:

Single blinded randomized controlled trial (examiner).

Participants:

This study will be conducted on 60 patients with lumbar spondylosis. Patients will be randomly assigned into 3 groups (https://www.randomizer.org). The control group (n=20) will receive core stabilization. The 1st experimental group (n=20) will receive core stabilization in addition to thoracic mobility exercises. The 2nd experimental group (n=20) will receive core stabilization in addition to hip mobility exercises.

Inclusion criteria:

1. Patients will be referred from an orthopedic surgeon with confirmed diagnosis of lumbar spondylosis with imaging findings (MRI, CT or X-ray reports within the last 6 months) (Battié et al., 2014).
2. 2.Duration of patient’s symptoms will be more than 3 months (Oliveira et al., 2022).
3. 3.Patients' age will range from 40-60 years (Kalichman & Hunter, 2008).
4. 4.Localized back pain and pain radiating to lower extremities with no distal involvement below knee with an NPRS more than 3 (Thompson et al., 2021).

Exclusion Criteria:

1. 1.Spinal or hip surgery history (Williams et al., 2022).
2. 2.Red Flags: Cauda equina syndrome, fracture, infection, malignancy (Finucane et al., 2020).
3. 3.Neurological Disorders: Parkinsonism, multiple sclerosis, or other neurological deficits (Odzimek et al., 2023).
4. 4.Inflammatory Conditions: Rheumatoid arthritis, ankylosing spondylitis, or infectious spinal disorders (Lee et al., 2018).
5. 5.Cognitive Impairment: Unable to understand or follow instructions (Martinez et al., 2024).
6. 6.Pregnancy.

Sample Size Calculation:

A priori power analysis for ANOVA, repeated measures, within-between interactions was used with an effect size of 0.28, alpha level (α) = 0.05, and power (1-β) = 0.95. The estimated sample size required was 54 participants, which was increased to account for potential dropouts as shown in **(Figure 1).** Thus, the total sample will include 60 participants, randomly allocated into 3 equal groups (n= 20 per group).

Sample size was calculated using G*Power software version 3.1.9.7, referencing effect size data of pain severity from a recent study studying the effects of thoracic and hip joint mobility exercise with lumbar stabilization exercise on pain and balance **(Choi and Kim, 2023).**

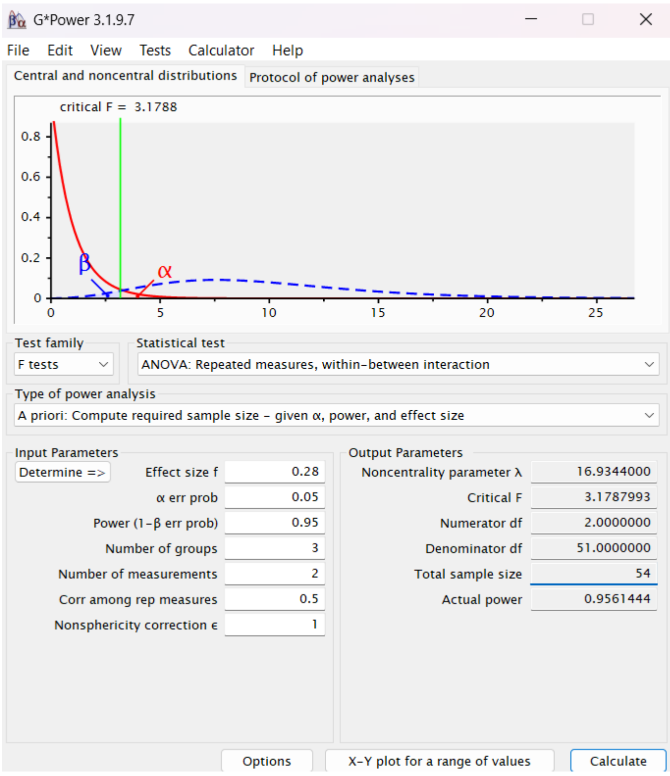

Figure (1): Sample size calculation.

Ethical Consideration:

- The study's protocol will be reviewed and approved by the research ethical committee, faculty of physical therapy, Cairo University.
- All patients will sign an informed consent form after receiving information on the purpose of the study, procedures, possible benefits and risks, privacy and use of data **(Appendix I).**

Instrumentations:

1. Arabic version of numerical pain rating scale (NPRS-Ar):

The Numerical Pain Rating Scale is an 11-point (0-10) pain intensity measuring scale, it is a highly sensitive pain measuring scale and is widely preferred over Visual Analog Scale (VAS) due to its simplicity and clinical applicability **(Alghadir et al., 2018).** It ranges from zero to ten where the score zero represents no pain while the score 10 represents the worst possible pain **(Kahl and Cleland, 2005; Ishtiaq et al., 2023).** NPRS has high test–retest reliability (r = 0.95 to 0.96) **(Ferraz et al, 1990).** Additionally, the NPRS demonstrates strong correlation with other established pain measurement scales, making it a reliable tool for clinical assessments **(Alghadir et al., 2018).** It has been translated and validated into Arabic language by **Alghadir et al., (2016) (Appendix II).**

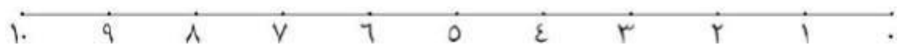

Figure (2): Arabic NPRS

2. Modified Oswestry Disability Index Arabic Version (MODI-Ar):

The Modified Oswestry Disability Index is a 10-item disease-specific questionnaire measuring functional disability caused by low back pain in the following categories: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling, and employment/homemaking **(Fairbank & Pynsent, 2000).**

The modified version was used as it replaced the "sex life" category with "employment/homemaking" that is more culturally appropriate and clinically relevant to multinational populations and particularly in Arabic-speaking populations where the issue of sexual relationships may be culturally sensitive **(Ramzy, 2008).**

MODI-Ar has excellent internal consistency (Cronbach's α = 0.94) and test-retest reliability (ICC = 0.91). Construct validity demonstrates good correlation with SF-36 physical functioning (r = -0.82) and moderate correlation with pain intensity (r = 0.67) **(Alnahdi, 2025).**

It was translated and validated into Arabic language by **Alnahdi, (2025) (Appendix III).**

3. Back Range of Motion Device (BROM):

The BROM device is a gravity-dependent dual inclinometer system that is used specifically to measure spinal range of motion in the sagittal and frontal planes with pelvic compensation movements excluded as shown in **(figure 3) (Chen et al., 2022).** BROM has high inter-rater reliability (ICC = 0.92-0.96) and intra-rater reliability (ICC = 0.94-0.98) for the measurement of lumbar flexion and extension. Concurrent validity with radiographic measurements is highly correlated (r = 0.87-0.93) **(Kumar & Singh, 2021).** It has the following advantages; High accuracy, being portable and simple to use in the clinical setting. Model used in this study: BROM II Deluxe (Performance Attainment Associates, Roseville, MN, USA).

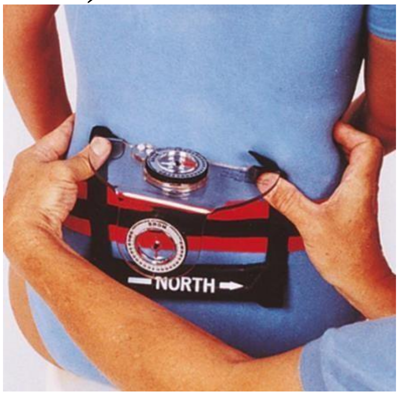

Figure (3): Back Range of Motion Device (BROM). (Seo et al., 2022)

4. Spinal Mobility Test (Modified Schober Test):

The Modified Schober Test is a clinical measurement of lumbar spine flexion where 15cm above and 5cm below the lumbosacral junction (L5-S1) is marked and the difference in distance is measured on forward flexion **(Kumar et al., 2019).** Inter-rater reliability (ICC = 0.89-0.94) and intra-rater reliability (ICC = 0.92-0.96). Criterion validity with radiographic lumbar flexion measurements with strong correlation (r = 0.81-0.86) **(Tousignant et al., 2005).** Normal Values: 5-7cm increase in distance is normal during full flexion in healthy adults **(Hershkovich et al., 2022).**

5. Short Form 36 Health Survey Arabic version (SF-36-Ar):

The SF-36 is a general health-related quality of life instrument measuring 8 domains: physical functioning, role limitations caused by physical problems, pain, general health perceptions, vitality, social functioning, role limitations caused by emotional problems, and mental health **(Ware & Sherbourne, 1992).** Each domain is scored 0-100, and higher scores indicate better health status. Physical Component Summary (PCS) and Mental Component Summary (MCS) provide overall physical and mental health scores **(Johnson et al., 2012).**

The Arabic version was validated by **El-Kalla, (2016)** to fit Arab populations, including simplifying language and providing culturally relevant examples **(Appendix IV).** SF-36 Arabic version demonstrated high internal consistency across all domains (Cronbach's α = 0.83-0.94) and test-retest reliability (ICC = 0.78-0.92). Construct validity confirmed through confirmatory factor analysis for the 8-factor structure **(El-Kalla, 2016).**

6. Tampa Scale for Kinesiophobia Arabic Version (Tampa-Ar):

The Tampa Scale for Kinesiophobia is a 17-item questionnaire that measures fear of movement and re-injury in patients with chronic musculoskeletal pain, on a 4-point Likert scale (1=strongly disagree to 4=strongly agree) **(Weermeijer & Meulders, 2018).** It varies from 17-68, where higher scores indicate a greater fear of movement. Cut-off point of ≥37 indicates high kinesiophobia in the Arabic-speaking population **(Al-Shudifat et al., 2020).**

Adaptation into Arabic was done by **Al-Shudifat et al., (2020)** following guidelines with forward-backward translation, discussion with an expert panel, and pilot testing on chronic low back pain patients **(Appendix V).** Tampa-Ar shows good internal consistency (Cronbach's $\alpha = 0.86$) and test-retest reliability (ICC = 0.84-0.89) **(Al-Shudifat et al., 2020).**

<u>Assessment Procedures</u>

All assessments will be conducted at baseline (pre-treatment) and **after 6 weeks** of intervention (post-treatment) by **blinded assessors** to ensure objectivity and minimize bias. Assessment procedures will include:

1. Pain severity:

Using the Arabic NPRS **(Appendix II)**, Patients will select a value between (0-10) based on intensity of pain. Where (0) means no pain and (10) means maximum pain experienced **(Kahl and Cleland, 2005; Ishtiaq et al., 2023).**

2. Disability:

Using the Arabic MODI **(Appendix III)**, Patients will be instructed to choose the best answer of the possible answers which describes the level of function and disability during daily activities in each of items of the questionnaire **(Alnahdi, 2025).**

3. Lumbar Range of motion:

The Back Range of Motion (BROM) device will be utilized to measure the lumbar range of motion (ROM), as a valid and reliable measure of spinal motion **(Kumar & Singh, 2021; Chen et al., 2022)**, according to established procedures **(Madson et al., 1999)**. After palpating and marking the spinous processes of T-12 and S1 with adhesive dots, a warm-up trial for each plane of motion will be completed by patients. The BROM device will be used to measure active ROM in the order of flexion/extension, right/left lateral flexion, and right/left rotation. Once the data for each movement was taken, the BROM device was removed, and the skin markers were reapplied after a 10-15 second rest period. Each motion will have three trials, and data from the three trials will be averaged and used for analysis in order to maximize reliability.

<u>a- For flexion/extension measurements:</u>

Each patient will stand upright and assume a comfortable erect posture with body weight evenly distributed and feet shoulder-width apart. The BROM unit will be mounted by the examiner. The patient will be asked to grasp the ends of each Velcro strap and cross them near the symphysis pubis, where they will be become firmly attached to each other. The removable L-shaped slide arm for the flexion and extension unit will be placed in the slot of the frame, and the short arm tip will be placed on the adhesive dot marking the T-12 spinous process.

The therapist will record the starting position on the upper scale of the frame mounted to the sacrum. The examiner will hold the tip of the short side of the slide arm unit in constant contact with the patient's T-12 spinous process and will instruct to: "Bend forward as far as you can, trying to reach your fingertips to the floor. Do not bend farther than is comfortable, and do not cause any back pain". The examiner will stand on the opposite side of patient. The initial flexion reading will be subtracted from the full flexion reading to obtain full trunk flexion. Then the examiner will tell the patient to return to the starting position, as shown in **(figure 4) (Madson et al., 1999).**

After that, the examiner will instruct the patient to, "Bend backward as far as you can, and keeping your hands alongside the back of your thighs. Do not bend farther than is comfortable, and do not cause back pain". The examiner will keep constant contact of the L-shaped arm against the red dot marking the T-12 spinous process. The difference between the baseline measurement and the position of full extension will be recorded as trunk extension. Then the examiner will ask the patient to return to the starting position, as shown in **(figure 4) (Madson et al., 1999).**

Figure (4): Flexion/extension measurements. (Madson et al., 1999)

b- For lateral flexion measurements:

Patients will stand parallel to a wall to avoid the substitution pattern of forward trunk flexion. The examiner will place the BROM unit parallel to and along a line over the red dot marking the T-12 spinous process. The lower ribs of the patient will be grasped by the examiner's fingers to keep the BROM unit in place. The needle of the inclinometer pointed to zero, marking the starting position for lateral flexion. When the patient flexes laterally, the BROM unit becomes a part of the patient’s truncal movement. Instructions will be given to the patient: "Slide your right hand down the side of your right thigh and try to reach for your knee. Be sure to keep your weight on your left leg and foot to avoid hiking your left hip and lifting your left heel off the floor. Do not bend farther than is comfortable, and do not cause back pain". The examiner will stand behind the patient during measurement. The same commands will be given for left lateral flexion measurements except that the patient will place body weight on the right leg and foot, as shown in **(figure 5) (Madson et al., 1999).**

Figure (5): Lateral flexion measurements. (Madson et al., 1999)

c- For rotation measurements:

During rotation measurements, the magnetic yoke will be placed around the patient's pelvis at the level of the iliac crests. A buckle held the magnetic yoke in place. The patient will sit on a stool facing west so that the end of the magnet with north polarity will be aligned in the correct direction. The examiner will place the BROM unit parallel to the ground and along a line over the red dot marking the T-12 spinous process. The lower ribs of the patient will be grasped by the examiner's fingers to keep the BROM unit in place. During axial rotation of the spine, the BROM unit becomes a part of the patient's truncal movement, as shown in **(figure 6) (Madson et al., 1999)**.

Each patient will be told to place hands across chest and then instructed, "Twist your trunk to the right as far as you can go. Do not twist farther than is comfortable, and do not cause back pain". The examiner will stand behind the patient. The same commands will be given for left rotation, as shown in **(figure 6) (Madson et al., 1999)**.

Figure (6): Rotation measurements. (Madson et al., 1999)

4. Spinal mobility:

Using the Modified Schober Test, Patient will be standing. The examiner will mark both posterior superior iliac spine (PSIS) and then will draw a horizontal line at the center of both marks. A second line is marked 5 cm below the first line. A third line is marked 10 cm above the first line. Patient will be instructed to flex forward as if attempting to touch his/her toes. The examiner re-measures the distance between the top and bottom line **(Rezvani et al., 2012).** Three trials will be conducted and the mean of the three trials will be chosen for the purpose of data analysis

5. Health Related Quality of life:

Using the Arabic SF-36 **(Appendix IV),** Patients will be asked to fill out the questionnaire (tick boxes) by themselves and then it is scored by a clinician or researcher **(El-Kalla, 2016).**

6. Fear of movement

Using the Arabic Tampa **(Appendix V),** Patients will be asked about any excessive, irrational, and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or re-injury **(Al-Shudifat et al., 2020).**

7. Adherence

Individuals will be followed in a checklist at each session with the date of the session. The absence of the participant for two sessions will lead to consideration of being drop out.

<u>Treatment Procedures:</u>

- The control group (n=20) will receive core stabilization (3 sessions/ week for 6 weeks)
- The 1st experimental group (n=20) will receive core stabilization in addition to thoracic mobility exercises (3 sessions/ week for 6 weeks)
- The 2nd experimental group (n=20) will receive core stabilization in addition to hip mobility exercises (3 sessions/ week for 6 weeks).
- Adherence will be monitored using attendance logs and exercise checklists.
- Any adverse effects or symptom exacerbation will be recorded.

A) <u>Core stabilization exercises (control group):</u>

All 3 groups will receive core stabilization exercises based on work of **(Kuzu et al., 2025).** Each exercise session will be performed for approximately 35 minutes with 5 min warm-up.

Before starting the exercise, patients will be taught to reduce the lumbar lordosis by contracting and drawing in the abdominal muscles and to find the lumbar and pelvic neutral position by moving the pelvis forwards and backwards (pelvic tilt, bridge, bird-dog and plank etc.).

In each session, the neutral position will be found first and attention will be paid to maintain the neutral position throughout the exercise. In addition, core stability exercises including simultaneous contractions of the multifidus and pelvic floor muscles will be given in different positions such as supine, prone, crawling, bridge, kneeling, sitting and standing, as shown in **(figure 7).** The exercises will consist of 3 levels (from easy to difficult). In the advanced level exercises, patients will be asked to maintain the neutral curvature of the lumbar spine, resistance limb exercises will be added and the exercises will be completed gradually. Each exercise will be performed for 3 sets of 8–10 repetitions, depending on the patient's tolerance.

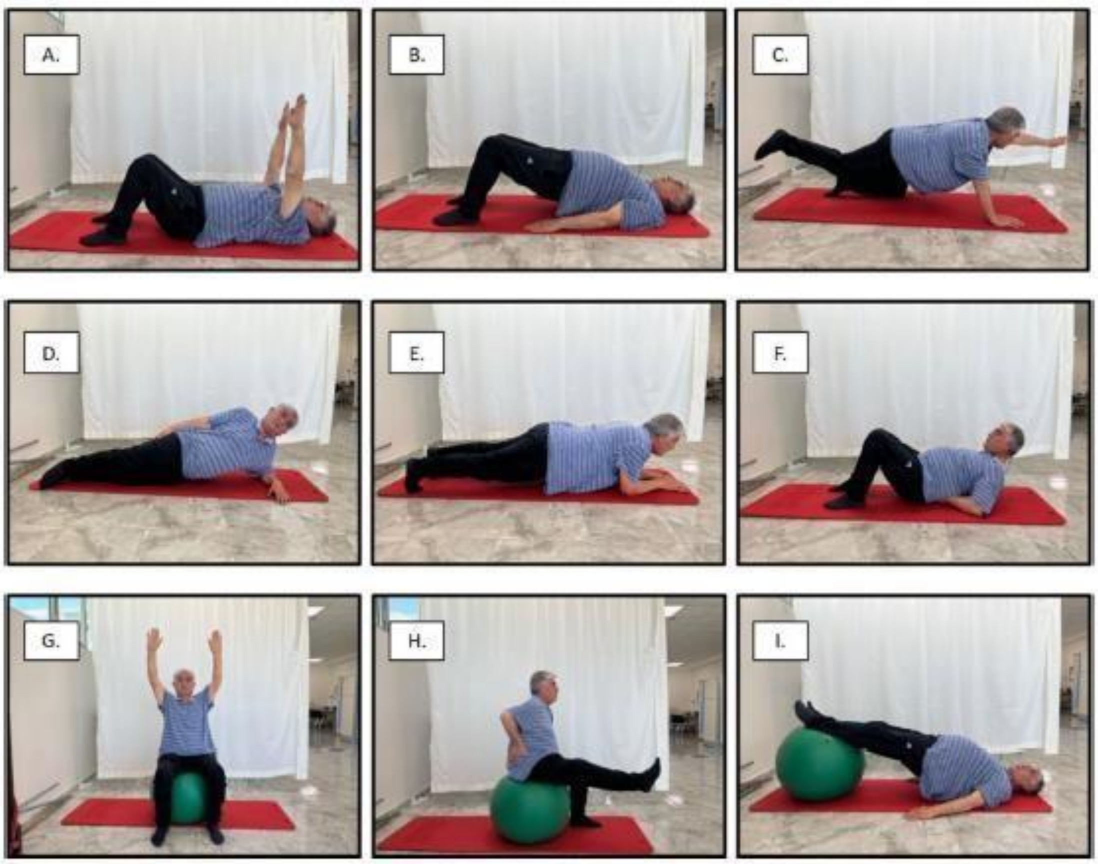

Figure (7): Core stabilization exercises (Park & Kim, 2020)

B) <u>Thoracic Mobility Exercises (1st experimental group only):</u>

It was developed based on the exercise described by **Henegahn et al., (2020)** and **Choi & Kim, (2023),** the exercise will consist of movements in all directions of thoracic spine flexion, extension, lateral flexion, and rotation.

In the thoracic spine extension exercise, both hands will be locked behind the wrists and the back will be placed on a foam roller with the feet positioned flat on the floor. The knee will be maintained at 90° to perform the extension exercise on the foam roller, as shown in **(figure 8A).** Additionally, the hands will be locked with the elbow on a chair. After kneeling, the hip will be moved toward the heels to extend the thoracic spine, as shown in **(figure 8B).**

In the thoracic spine flexion exercise, the thoracic spine will be flexed by moving backward until the hip touched the heels in a quadruped position, as shown in **(figure 8C).**

The rotation exercise will be conducted with patients lying on their sides. The elbows will be straight and the palms will be held together. The leg facing the ceiling will be bent to the level of the stomach. Then, the arm facing the ceiling will be moved backward in a large arc to rotate the thoracic spine, as shown in **(figure 8D).** Another thoracic spine rotation exercise will be conducted as follows in a kneeling position, the hip will touch the heels; the hand in the direction of rotation will be placed behind the neck and the elbow of the opposite arm will be placed on the floor; then, the torso will be slowly rotated toward the ceiling, as shown in **(figure 8E).**

For lateral flexion of the thoracic spine, both hands will be locked behind the neck with the participant seated on a chair and the torso will be then flexed laterally, as shown in **(figure 8F).**

Each exercise will be performed for 3 sets of 10 repetitions.

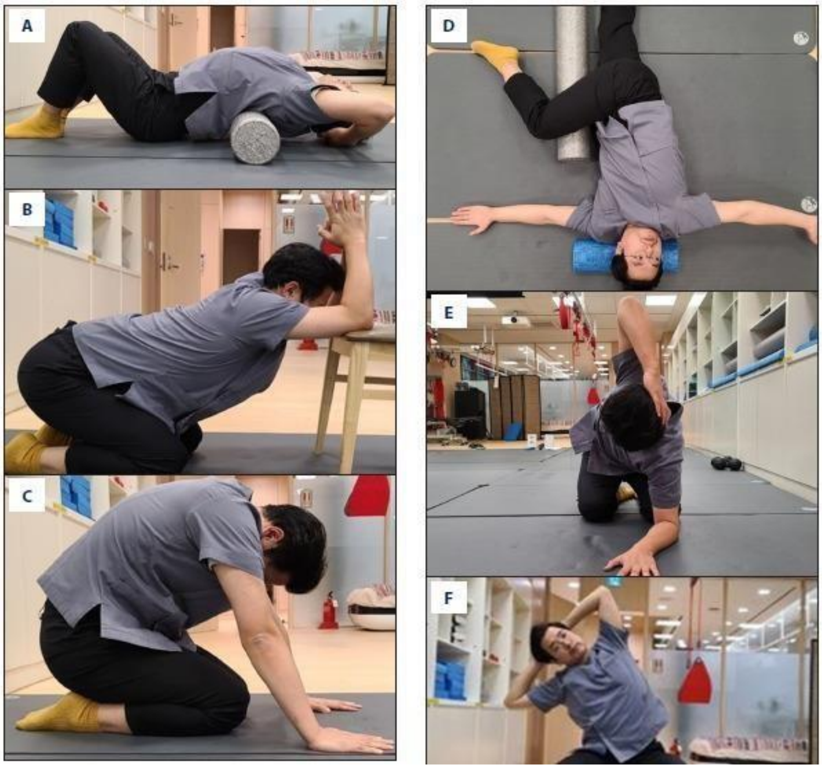

Figure (8): Thoracic Mobility Exercises; A) Thoracic extension with foam roller. (B) Thoracic extension with chair. (C) Thoracic flexion in quadruped position. (D) Thoracic rotation in side lying. (E) Thoracic rotation in a kneeling position. (F) Thoracic lateral flexion in sitting position. (Seo et al., 2022)

C) <u>**Hip Mobility Exercises (2nd experimental group only):**</u>

It was conducted based on the exercise described by **Demirtas et al., (2023)** and **Choi & Kim, (2023).** The patients will perform 8 different hip mobility exercises; reverse v-ups, butterfly, frog, internal rotation with foot rise, pike, revolved crescent lunge, pigeon, lunge on the knee, as shown in **(figure 9).** Each exercise will be performed for 2 sets of 20 seconds.

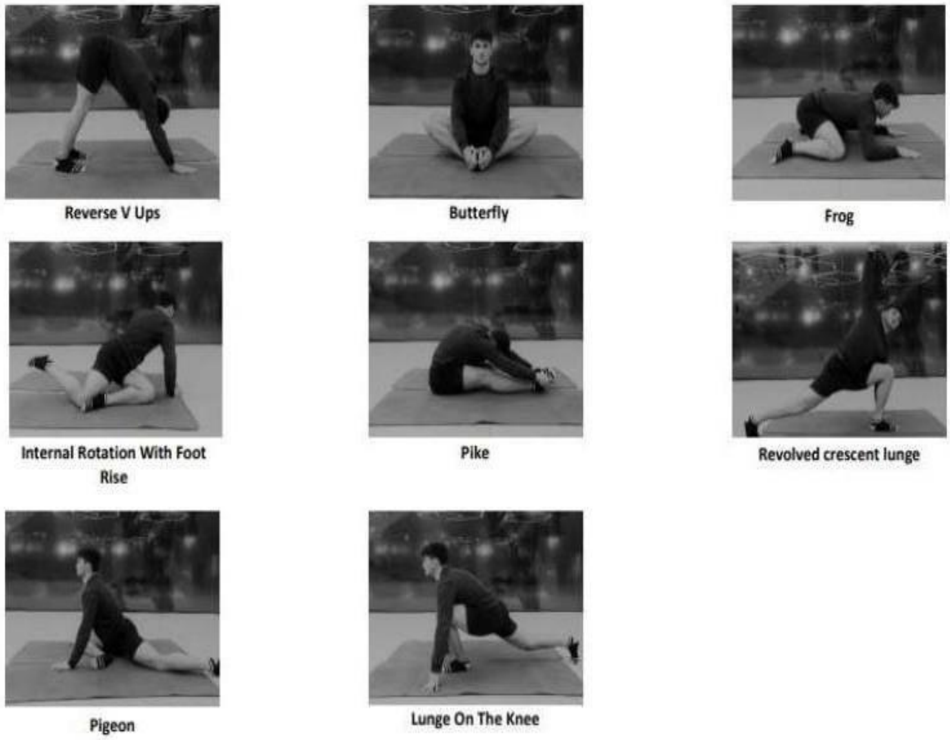

Figure (9): Hip Mobility Exercises. (Demirtas et al., 2023)

<u>Data analysis and statistical design</u>

Statistical analysis will be performed using SPSS software for Windows, version 25.0 (SPSS, Inc., Chicago, IL) with Alpha level set at 0.05.

- Data will be screened for normality assumption, homogeneity of variance, and presence of extreme scores.
- Descriptive statistics will be calculated for all groups at baseline and after 6 weeks.
- ANOVA, repeated measures, within-between interactions model will be utilized to determine any differences between the mean change scores of groups regarding all outcomes.
- Bonferroni adjusted p-values for every outcome measure to protect against the possibility of type I error.

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