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A systematic review and meta-analysis with radiological correlation on the efficacy of spine stabilizing exercises in chronic low backache

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Abstract
Objective: The objective of this prospective study and systemic review is to analyze the efficacy of stabilizing exercises in the management of spondylolisthesis. Nonspecific low back pain (NSLBP) is a large and costly problem. It has a lifetime prevalence of 80% and results in high levels of healthcare cost. It is a major cause for long-term sickness amongst the workforce and is associated with high levels of fear avoidance. Stabilizing (or core stability) exercises have been suggested to reduce symptoms of pain and disability and form an effective treatment. Despite it being the most commonly used form of physiotherapy treatment there is a lack of positive evidence to support its treatment of NSLBP, and compare any effectiveness to other forms of exercise.
Aim: The primary aim of this analysis is to systematically review the most current up to date literature to determine whether stabilization (or core stability) exercises are an effective therapeutic treatment compared to an alternative treatment for the people with Spondylolisthesis. The secondary aim is to determine if stabilization exercises are as effective as other forms of exercise, and to evaluate findings by meta-analysis if appropriate.
Methods: A total of 50 non-surgically managed patients with degenerative spondylolisthesis were examined daily for a minimum of 10 days follow-up evaluation. Further follow-up was done evaluation for 1 month, 3 months, and 6 months period. Radiological changes, changes in clinical symptoms, and functional prognosis were surveyed. A comparison of pre-exercises, post exercises and a period of 6 months follow-up for Health-Related Quality of Life using Short-Form 36 Questionnaire was also done.
Clinical implications: This article addresses the different phases of the assessment of a patient with SPL, including history, imaging, physical exam and questionnaires on disability and cognitive-behavioral components. Regarding conservative treatment, self-management approaches and graded supervised training, including therapeutic relationships, information and education, are explained. Primary therapeutic procedures for pain control, recovery of function and mobility through therapeutic exercise, passive mobilization and antalgic techniques are suggested.
Result: A total of 10(20%) of 50 patients who had no neurological deficits at initial examination remained without neurological deficits after 6 months of follow-up. 40(80%) of the 50 patients who had neurological symptoms, such as intermittent claudication, radiating pain at initial examination experienced symptomatic relief.
Conclusion: Stabilizing exercises are effective in the management of spondylolisthesis. Physiological and biomechanical factors such as correction of the displaced disc, opening of the foramina increase in intervertebral spaces and reduction in herniation size with negative intradiscal pressure may be possible mechanisms.

Keywords: Low back pain, lumbar disc herniation, stabilizing exercises, spondylolisthesis, sciatica, physiotherapy intervention, exercise therapy, core stability, stabilization treatment

Introduction
Non-specific low back pain (LBP) can be described as low back pain without an underlying cause or disease and has a lifetime prevalence of 80% [1, 2]. Point prevalence ranges from 12% to 33% with 90% of acute episodes recovering within six weeks [1, 3]. However, 62% of people experiencing their first episodes of LBP will develop chronic symptoms lasting longer than one year.

In India, Patients with LBP are routinely referred to physiotherapy [4]. Treatment can involve a number of different techniques ranging from spinal manipulation, mobilization, advice, general exercises and specifically tailored exercises. Therapeutic exercise regime aimed at back muscle was developed, designed to 'retrain' motor skills and the activation dysfunction [5].

Despite doubts raised about this link between back pain and muscle activation, and the effectiveness of such an exercise regime (known as stabilization or 'core stability' exercises) it has grown in popularity and now ranks the most common form of physiotherapy treatment for back pain [6, 7-8].

Macedo et al [9] included studies published up to June 2008 and concluded that stabilization exercises were no better than general exercise. In 2012 Wang *et al.* [10] carried out a systematic review and also concluded there was no significant difference between 'core stability' and general exercises [10]. However, Wang *et al.* narrow definition of 'core stability' exercises was "exercises performed on unstable surfaces", rather than a broader definition based upon specific muscle activation. Furthermore, they only included randomized controlled trials (RCT) that specifically compared intervention versus general exercise, rather than any other alternative treatment, and only included people suffering back pain for more than three months. In contract to these results more recently Byström *et al.* [11] reported that stabilization exercises were more favorable than general exercises. They searched the literature up to October 2011, but did not limit their participants to non-specific back pain and had far stricter inclusion criteria.

Introduction

Spondylolisthesis (SPL) is the term employed to define a displacement of the vertebral body in reference to the bordering vertebral bodies. Meyerding classified SPL in relation to the amount of vertebral slippage related to the caudal vertebrae measured by plain radiography.

Correlation of the percentage of slip with the Meyerding classification grade [12, 13].

Table 1: Correlation of the Percentage of slip with the Meyerding Classification Grade

Meyerding classification	Percentage of slip
Grade I	0-25
Grade II	25-50
Grade III	50-75
Grade IV	75-100
Grade V	> 100 (spondyloptosis)

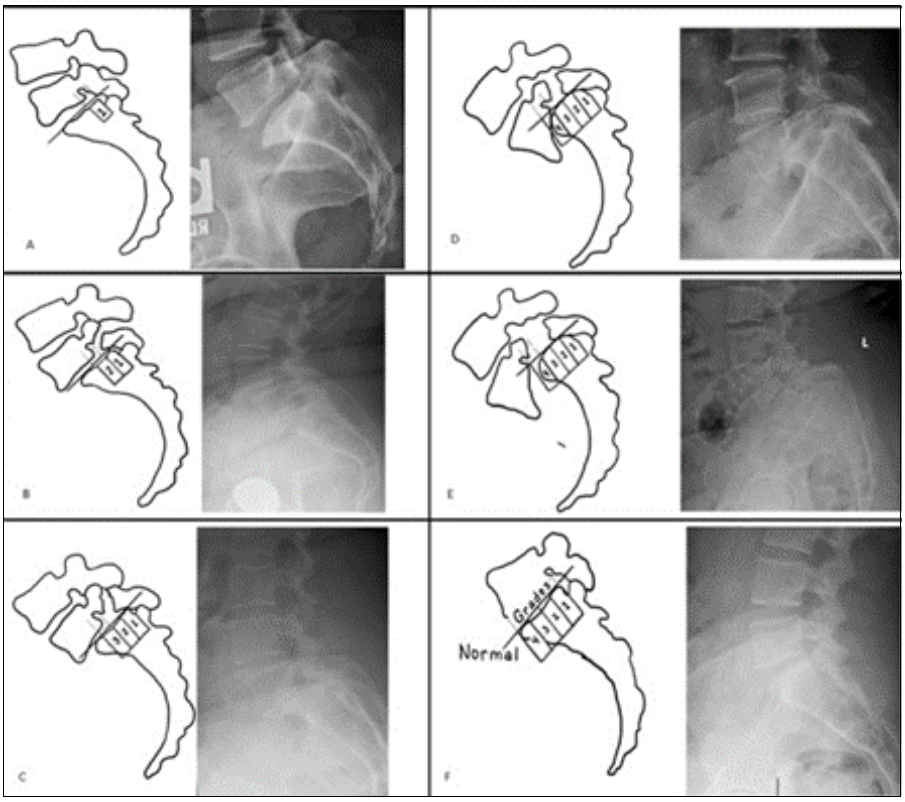


Fig 1: According to the Meyerding classification Grades from A to E; (F) this image shows all grades compared with normal alignment.

SPL is defined isthmic or degenerative, based on its aetiology. Isthmic SPL is the consequence of a spondylolysis, which is a congenital defect or post-traumatic break in the pars interarticularis. Spondylolysis is the most common "specific" pathology within the adolescent population complaining of low back pain (LBP) [14, 15].

Degenerative SPL is mostly caused by degenerative arthritis or disorders of the disc space. In adulthood and elderly, SPL is associated with degeneration of facet joints, smaller stabilizer muscle thickness at rest and during contraction, and overuse of stabilization muscles [16, 17], hypermobility at the SPL level is compensated by hypomobility of other spinal levels, mostly the thoracic ones, and vice-versa [18]. Hypermobility of the segments adjacent to the one involved by SPL also has been observed [19]. Phan and colleagues divided SPL patients into stable and unstable groups, based on the level of mobility during flexion and extension movements [19].

Disc prolapse is more frequently seen in the lumbar region as compared to any other region and most common at L4-L5 and L5-S1 level [20-22]. Radicular pain is one of the most common and disabling symptoms [23-25]. It may lead to sensory and

motor deficits and leaves the person incapacitated [26, 27]. Diagnostic evaluation is very challenging and sometimes physicians are left with no choice but to make the diagnosis of LBP with symptoms only. Magnetic resonance imaging is one of the choices of examination for diagnosis, as it has high sensitivity and specificity [28, 29].

Both conservative and surgical interventions can be used for the treatment [30-32]. In the last decade, efforts have been done to minimize the need for spinal surgery [33, 34]. As per clinical guidelines of the "National Institute for health & care excellence 2016," first preference should be given to conservative treatment, such as medicine, support, advice, and exercise therapy [35]. Other interventions such as traction, taping, neural mobilization, and electrotherapy are also recommended for conservative treatment [35-38].

Surgical intervention (e.g.: Lumbar Discectomy) is required, when the patient does not respond to conservative treatment.

Assessment

Assessment of a patient with symptomatic lumbar SPL includes history, imaging, and physical exam, which should also help to identify the so-called red and yellow flags. Red flags are signs and symptoms that may raise suspicion of serious spinal pathology (e.g. Cauda equina syndrome, fracture, malignancy, and infection) and indicate that further investigation or referral is warranted. Yellow flags indicate psycho-social obstacles to recovery and can be related to passive coping strategies, pain catastrophizing, fear-avoidance believes, poor self-efficacy, anxiety, and depression as well as environmental factors [39].

Pain location alone does not help in differentiating symptomatic lumbar SPL from non-specific LBP. In fact, pain may be located both in lumbar area and/or referred to the lower limb/s. Taking into consideration that LBP comes from different causes, other characteristics must be considered to do a differential diagnosis between conditions similar to non-specific LBP (in which SPL is present but not relevant for the symptoms' characteristics), and other conditions in which LBP is logically related to SPL, when lumbar instability and its consequences are the most important findings. Concerning the first condition, a clinician could expect a worsening of symptoms in discogenic pain by forward bending, whereas pain due to facet joints degeneration is provoked by spinal extension and rotation [40]. In the case of LBP related to SPL, pain worsens by prolonged static postures and/or movements within the so-called "neutral zone" according to Panjabi [41].

When SPL is associated with compression of a nerve root in the lateral recess or in the foramen, patients may report paresthesia, reduction of sensitivity, and weakness in lower extremity [42]. In case of spinal stenosis, neurogenic claudication can be reported by patients together with difficulty in walking two to three blocks and doing their own shopping as well as getting in/out of a car [43, 44].

Physical examination

The most used test for recognizing the presence of forward slipping is the step-off sign/low midline sill sign, when the overlying spinous process is identified as anterior to the underlying one, during the inspection or palpation of lumbar spine in standing position. Concerning lumbar passive motion, the Posterior Shear Test [PST], also called the Segmental Spring Test or Passive Intervertebral Movement Test, aims to identify segmental hypermobility and/or provoke pain through passive posterior-anterior mobilization of the SPL level [45].

Provocation/alleviation tests include the Prone Instability Test (PIT), the Passive Lumbar Extension Test (PLET), the Active Straight Leg Raising (ASLR), and the recently proposed Lumbar Rocking Test (LRT).

In the PIT the patient lies prone with the body on an examining table with legs over the edge and feet resting on the floor. While the patient rests in this position with the trunk muscles relaxed, the examiner applies posterior to anterior pressure to each vertebral segment of the lumbar spine. Any provocation of pain is reported. Then the patient lifts the legs off the floor (the patient may hold table to maintain position) and posterior to anterior compression is applied again to the lumbar spine while the trunk musculature is activated. The test is considered positive if the pain is present in the resting position but subsides in the second position, suggesting lumbo-pelvic instability [46].

The PLET test is performed in prone position; both lower extremities are passively elevated by the clinician to a height of about 30 cm from the bed while maintaining the knees extended and gently pulling the legs. This test is positive when it reproduces lumbar pain or feeling of instability and such symptoms disappear when the lower legs are repositioned to the starting position.

The ASLR is performed in supine position and the patient is instructed to lift the leg 20 cm off the bed by maintaining both knees extended. A positive response is pain or inability to lift the leg off the bed; however, this response can vary from a slight difference in heaviness to complete inability. Next, an active or passive (using a belt) stabilization of the pelvis is applied to substitute or partially substitute the force required when the ASLR is painful or limited [39].

For the Lumbar Rocking Test, the patient lies comfortably in a supine position on a table. The clinician induces a gentle jerk to the lumbar spine after locking hip and pelvis in hyper-flexed position by gently pushing knee onto the abdomen. If the subject complains of severe pain in the lumbar region while pushing the knee onto the abdomen, the test is considered to be positive [47].

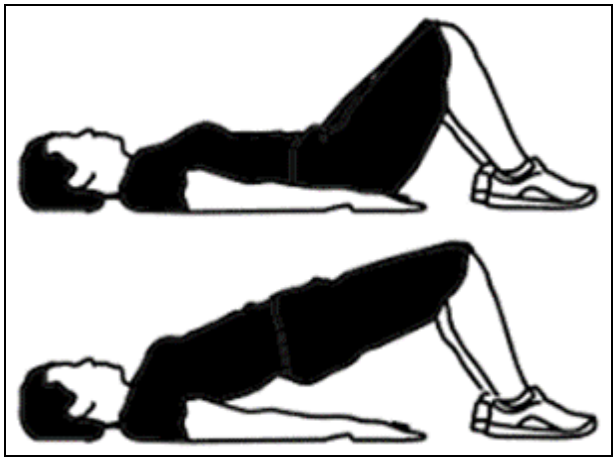


Fig 2: Supine Bridge

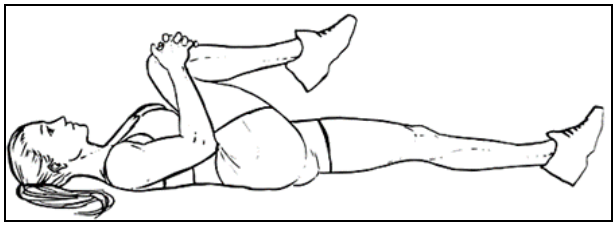


Fig 3: Knee to chest

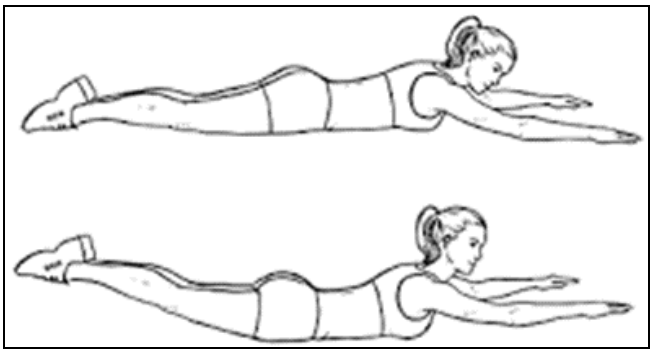


Fig 4: Prone Extension

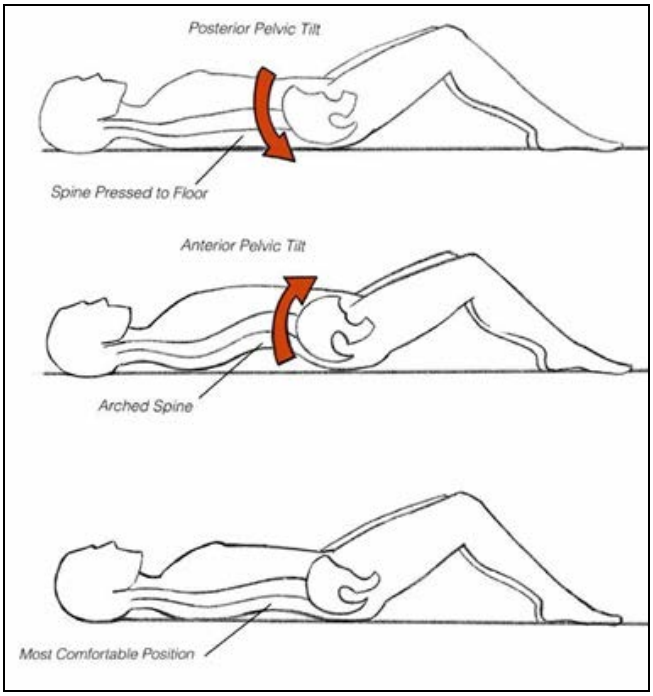


Fig 5: Pelvic Tilt

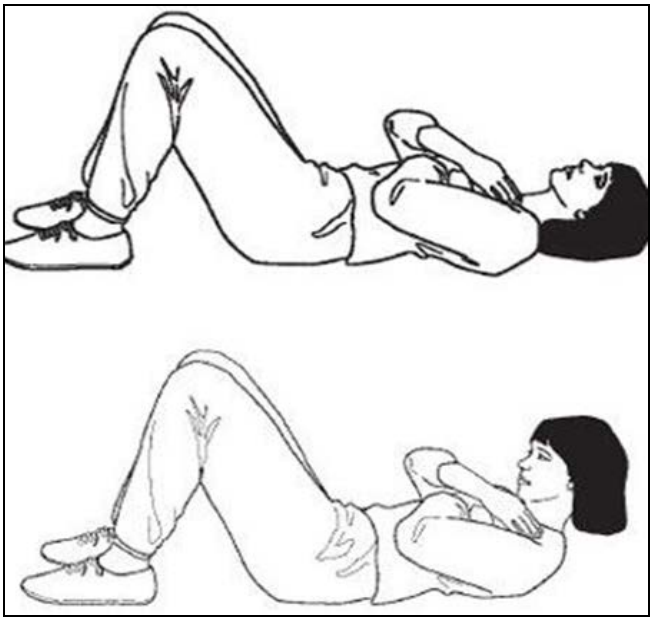


Fig 6: Curl- Up Exercise

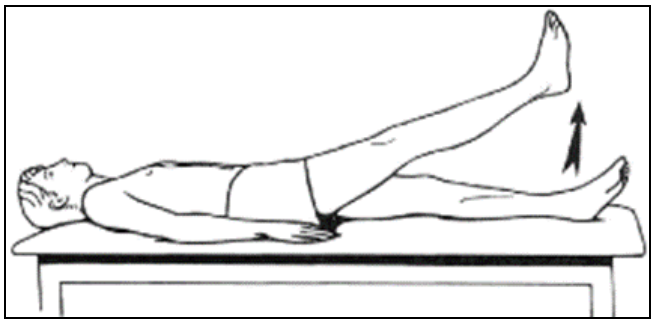


Fig 7: Straight leg Raising Test

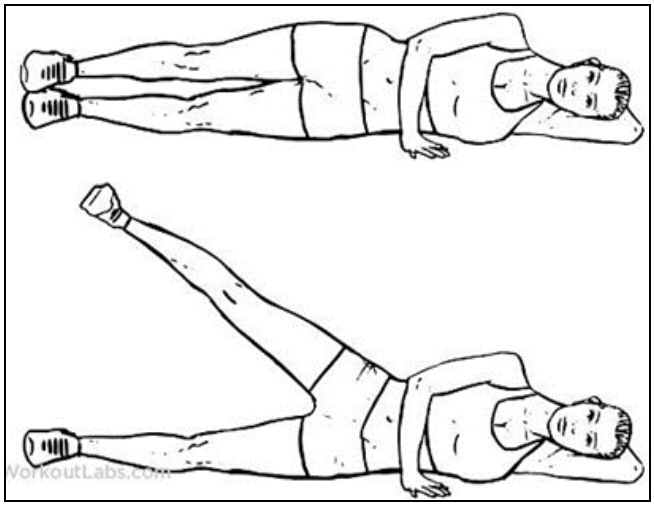


Fig 8: Side Bridge

Study design

50 Adults recruited from the general population with non-specific low back pain of a given time. Low back pain defined as, but not restrictive to, pain and/or stiffness between the lower rib and buttock crease with or without leg pain.

Primary intervention arm of stabilization, or 'core stability', exercises defined as: facilitation of deep muscles of the spine (Primarily Trans versus abdominis or multifidus) at low level, integrated into exercise, progressing into functional activity, according to Richardson *et al.* [48]. Norris *et al.* [49] or O'Sullivan *et al.* [50]. Comparison group of any other intervention, placebo or control were considered appropriate.

Methods

About 50 patients with LBP due to lumbar disk herniation were recruited. The subjects of this interventional prospective before-after study included 35 male and 15 female patients. All participants provided written informed consent and the study was approved by regional ethics committee. A comparison of pre-exercises, post exercises and a period of 6 month follow-up for Health-Related Quality of Life using Short-Form 36 (SF-36) Questionnaire was done.

Table 2: Gender Distribution

Gender	No. of patients
Male	35
Female	15

Table 3: Age Distribution

Age	No. of patients
35-45	10
46-55	24
56-65	14
65 above	2

Table 4: Mode of Injury

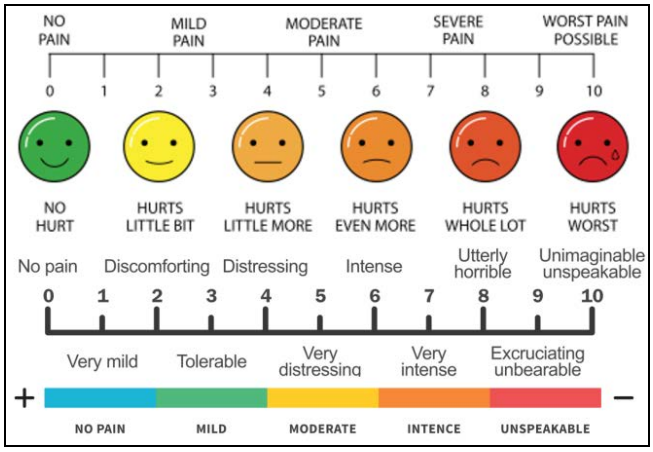
Causes	No. of patients
Trauma	4
Weight bearer	20
Long standing	2
Driver	5
Farmer	19

Fig. 1 to 7 show the various core stabilizing exercises which were taught to all the patients by the orthopaedician along with some guidance of the physiotherapist.

Inclusion criteria were men and women suffering from the LBPs due to disk herniation for more than 5 months, aged 20-70 years old. Exclusion criteria were a history of lumbar spine fracture, history of cancer, systemic steroid use, systemically ill, uncontrolled diabetes mellitus (DM), skeletal deformity, history of rheumatologic disorders, progressive motor weakness, incontinency and awakening pain at night.

They were examined by the specialists, and lumbar disk herniation was proved by physical examination and imaging studies. The physical examination included straight leg raise (SLR), reverse SLR, cross SLR, manual muscle tests, stretch tendon reflexes and sensory tests. Magnetic resonance imaging (MRI) was conducted for all the affordable patients. Majority of the participants had posterior or lateral disk herniation at L4-L5 or L5-S1 level in MRI study.

For pain evaluation progress during the study, we utilized a visual analog scale (VAS) which consists of the graduated line of 10 cm length ranging from 0 (no pain) to 10 indicating an extreme amount of pain. The evaluation of the pain was carried out before starting the first session, in 10 days after the beginning of the exercise protocol and at the time of discharge. The participants ought to specify their self-evaluation of the existent pain on VAS scoring system.



The exercise training protocol was as follows

Intervention consisted of 10 days to 1 week; two sessions for a day and each session lasted for 25-30 minutes of training. After a slight warm-up activity for 5 minutes, they exercised with the leg press device, lateral thoracic flexion and extension for the first three sessions. After the fourth session, the lateral thoracic rotation was added to the training program which required flexion as well as extension exercises. The patients who were unable to do the lateral flexion and rotation movements due to the pain were exempted from the activities.

Patients were asked to perform home exercises at the time of discharge comprising a sequence of 10 repetitions, a day. They were given illustrated information brochures describing the exercises and their purpose, and giving various tips and advice on how to perform them properly.

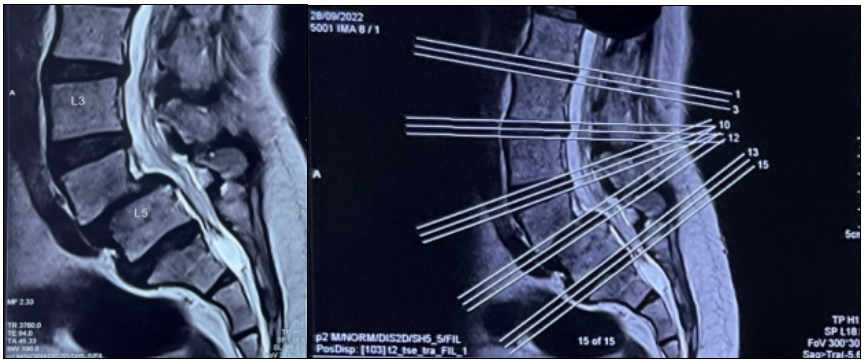


Fig 9: MRI Showing Grade 2 anterospondylolisthesis of L4-L5.

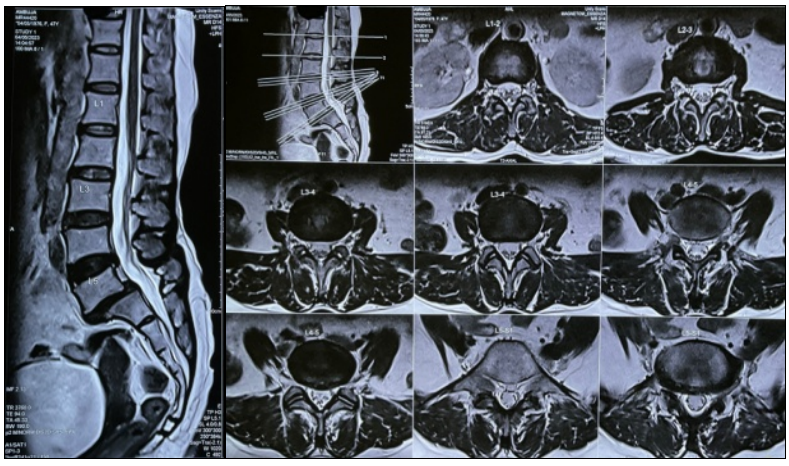


Fig 10: MRI Showing Garde 1 anterospondylolistheis of L5-S1.

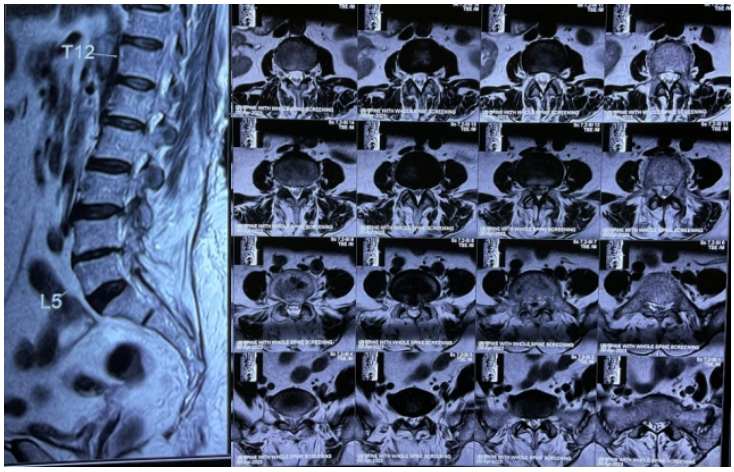


Fig 11: MRI showing decreased intervertebral disc space of L4-L5 with posterior disc bulge and end palte changes.

The above MRI pictures are a few of the many images obtained from the patients under this study, which shows the various segments and the degree of spondylolisthesis involved.

Discussion

In the present study, we compared the pain intensity before and after 1 week and 1 month of exercise in chronic LBP. This study reveals that after one month of core stabilization exercise protocol for chronic LBP patients reduces pain. There is no difference in short-term (1 week) between two genders but in longer term exercise (1 month), men improved a little bit more than female participants.

Various studies including those of Javadian *et al.* [8] have reported the consistency of the stabilizing exercises together with the routine exercises in decreasing the pain and increasing the performance ability rate as well as the muscular endurance with regard to its remaining effects during the 3 months after the treatment in the patients who suffered from the segmental lumbar vertebrates. The stabilizing exercises were a more effective than the routine ones.

LBP is a common disability across the globe [51].

Lumbar PIVD is one of the common causes contributing to LBP, which prompting individuals to seek medical help [31, 52, 53]. It has a significant effect on society in terms of epidemiology and economy, so there is a need for cost-effective and evidence-based interventions in the treatment of lumbar PIVD.

Physiological and biomechanical factors may play a major role in the management of chronic low back pain through physiotheraphy interventions. McMorland *et al.* stated that spinal manipulation can be a treatment of choice in case of failed medical management, as it improves 60% of cases in failed medical management of lumbar PIVD [54]. Manipulation decreases pain and improves spinal mobility [55]. The probable mechanism of manipulation in the management of PIVD can be the correction of the displaced disc and entrapped synovial fold [56, 52].

Traction improves disc height by opening the foramina and increasing in intervertebral space [57, 58]. Decrease in herniation after a certain degree due to traction might be the reason for symptomatic clinical improvements in lumbar PIVD [57, 54]. Traction restores normal mechanics that decrease stress on neural tissue and makes a significant change in H-reflex [59].

Non-surgical spinal decompression therapy can decrease intradiscal pressure, mobilize joint, and stimulate joint capsule receptor [58].

Reduction of herniation size with negative intradiscal pressure facilitates nucleus pulposus migration to the center of intervertebral disc [58, 60, 61].

In lumbar PIVD patients, “spinal mobilization with leg movement” (SMWLM) results in improvement in pain management, SLR, patient satisfaction, and a decrease in disability overtime [35]. Additional benefit of SMWLM may be due to sympathoexcitatory response and mobilization applied to the lumbar spine, which may facilitate decompression of nerve root along with hypoalgesic effect [35].

The result of the present meta-analysis shows significant improvement in pain and disability after physiotherapy management in patients of chronic low back pain.

Physiotherapy interventions do not have complications and are cost effective too in comparison to surgical treatment. Therefore, evidence-based physiotherapy management of low back pain is of immense clinical significance and it can be used as the first line of management before proceeding to invasive surgical procedures.

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