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REVIEW

The effect of exercise in the treatment of lumbar disc herniation: a systematic review

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Abstract

Background Systematic review explores the scientific evidence for the effectiveness of exercise interventions for lumbar disc herniation (LDH). LBP is a major cause of pain and disability worldwide and imposes huge costs on health systems, patients and society, with exercise being an important conservative treatment modality.
Objectives The aim of this review was to assess the effectiveness of different exercise treatments for LDH.
Methods Databases (MEDLINE, Pubmed, Cochrane, Scopus, Web of Science(WoS), ScienceDirect) were systematically searched for full-text articles published from 2018 to 23. Two researchers were involved in the research process. Studies evaluating pain, functional disability, quality of life, and transversus abdominis activation capacity in patients with LDH were included. Only studies published in English were considered. Randomized controlled trials (RCTs) with full-text availability, involving patients diagnosed with LDH who had not undergone surgery and were able to exercise, were included. The PEDro scale was used to assess the quality of evidence. According to the guidelines, the PEDro evaluation was carried out by the authors.
Results Twelve randomized controlled trials (RCTs) were included (PubMed: 8, ScienceDirect: 3, WoS: 1), involving 880 participants and comparing exercise with other approaches. The articles examined core stabilization exercises (CSE), motor control exercises (MCE), clinical Pilates, yoga, and various other types of exercise. Pain, functional disability, quality of life (QoL), and transversus abdominis (TrA) activation capacity were evaluated in patients with LDH. Increased pain, greater disability, decreased QoL, and reduced TrA activation capacity were reported in LDH. The latest search was conducted on November 20, 2023. This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
Conclusions Quick Response (QR) code home-based exercise intervention and neurodynamic mobilisation and motor control exercises, scored higher than the other trials in terms of methodological quality and quality of evidence.

Keywords Exercise · Intervertebral disc displacement · Lumbar region · Physiotherapy techniques · Sports

Abbreviations

BDI	Beck Depression Inventory
CLBP	Chronic Low Back Pain
CSE	Core Stabilization Exercises
CT	Computed Tomography
DPQ	Dallas Pain Questionnaire
FABQ	Fear Avoidance Beliefs Questionnaire
JOA	Japanese Orthopedic Association
LANSS	Leeds Assessment of Neuropathic Symptoms and Signs
LBP	Low Back Pain
LDH	Lumbar Disc Herniation
MCE	Motor Control Exercises
MRI	Magnetic Resonance Imaging
NPRS	Numeric Pain Rating Scale
NRS	Numeric Rating Scale
ODI	Oswestry Disability Index
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Controlled Trial

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RMDQ	Roland-Morris Disability Questionnaire
SBS	Sciatica Bothersome Scale
SF-36	The Short Form-36
S-LANSS	Self-report Leeds Assessment of Neuropathic Symptoms and Signs Scale
TrA	Transversus Abdominis
TENS	Transcutaneous Electrical Nerve Stimulation
VAS	Visual Analogue Scale
WoS	Web of Science
QR	Quick Response
QoL	Quality of Life

Introduction

Low back pain (LBP) is the leading cause of pain and disability worldwide, placing a costly burden on healthcare systems, patients, and society. LBP is often associated with acute lumbar disc herniation (LDH), which causes compression of spinal nerve roots and is usually associated with leg pain, low back pain, or both [1].

LDH affects approximately 1–3% of the population annually. It is most common in individuals between the ages of 30 and 50 [2]. LDH is one of the most common degenerative diseases and more than 95% occur at the L4/5 or L5/S1 level [3]. With age, the fibrochondrocytes in the intervertebral discs age and the production of proteoglycans decreases. This decrease in proteoglycans causes dehydration and disc collapse, increases tension on the annulus fibrosus, causes tears and cracks, and ultimately facilitates nucleus pulposus herniation [4]. Symptoms of LDH include radicular pain, low back pain (LBP), sensory abnormalities and weakness in the distribution of lumbosacral nerve roots, limited trunk flexion, aggravation of pain with exertion, coughing and sneezing, and pain that worsens with sitting as pressure on the nerve root increases by approximately 40% [5].

Conservative therapies, minimally invasive approaches, and surgical treatments are available for the management of LDH [6]. Conservative treatments are considered first-line options. Numerous conservative approaches have been developed and implemented in clinical practice, with reports indicating that they are the preferred choice for treating LBP [7]. Conservative treatment methods primarily include patient education, bed rest, medical interventions, exercise, physical therapy techniques, orthotics, and lumbar school programs. Among the primary physical therapy methods, electrotherapy techniques are frequently utilized. The most commonly used electrotherapy modalities in clinical practice include transcutaneous electrical stimulation (TENS), superficial heat (SH), and ultrasound (US). Healthcare professionals offer TENS as either a standalone treatment or in combination with medication for the symptomatic relief of inflammatory, neuropathic, and musculoskeletal pain. TENS is widely used by both patients and healthcare professionals due to its affordability, non-invasiveness, and ease of self-administration, particularly when used alongside medication. US is a non-invasive physical therapy modality frequently utilized by physical therapists for managing soft tissue lesions. US exerts both mechanical and thermal effects by enhancing blood flow and metabolic activity within tissues. It is delivered in the form of acoustic compression waves, with its thermal and mechanical effects inducing physiological changes in the targeted tissue. The mechanical effects of ultrasound (US) are believed to induce biochemical changes that promote tissue repair. The thermal physiological effects of US include localized increases in tissue temperature, enhanced blood flow, and improved tissue elasticity [8].

Surface heat therapies transfer heat through conduction or convection, leading to increased tissue temperature. Common superficial heat therapy methods include hot water packs (HP), hot towels, hot baths, saunas, steam therapy, heat wraps, heating pads, electric heating pads, and infrared heat lamps. The use of HP in superficial heat therapy has been reported to be effective for pain relief and tissue healing, supported by moderate evidence [9, 10].

Non-surgical treatment approaches primarily consist of basic therapy, self-function exercises, lumbar core stability muscle group training, physiotherapy modalities, medical treatment, psychological interventions, and traditional Chinese medicine [11].

The primary goal of exercise therapy is to enhance muscle and joint strength while improving muscle function and range of motion. This approach helps reduce pain and disability, accelerates recovery, and facilitates a return to normal activities.

Exercise therapies are designed or prescribed by healthcare professionals and encompass various types, durations, and methods. Examples of exercise therapies include general physical fitness programs conducted in a group setting, aerobic exercises such as walking programs, and targeted strengthening of specific muscles or muscle groups to enhance core stability [12].

Active exercise therapy is generally preferred. Several exercise programs are available for the treatment of symptomatic LDH, including aerobic activities, flexibility exercises, proprioception training, coordination drills, balance exercises, motor control training, and muscle-strengthening routines. Exercise therapy has been shown in the literature to be effective in reducing pain and improving function [13], but there is no consensus on which exercise is more effective. The aim of this review is to investigate the effectiveness of different types of exercise for LDH, as there is a lack of evidence in the literature as to which exercise is more effective in the treatment of LDH.

Materials and methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol for this systematic review was registered in the PROSPERO database under the registration number CRD42023485805.

Data sources and search strategy

Pubmed, ScienceDirect, WoS, Cochrane, SCOPUS and MEDLINE databases were searched to identify articles related to exercise approaches in LDH (2018–2023). In recent years, different exercise regimes, including remote exercise models, have been introduced with therapeutic applications in the clinical setting. This issue was previously addressed in a systematic review conducted in 2019 [7], and trials involving current exercise regimens conducted within the last five years were included in this systematic review. The most recent search was performed on November 20, 2023.

Two groups of keywords were developed, focusing on 'lumbar disc herniation' and 'exercise.' Each database was searched independently using a specific iteration of the search string: ('exercise' OR 'exercise movement techniques' OR 'exercise therapy' OR 'physical exertion' OR 'physical fitness' OR 'sports') AND ('lumbar disc herniation' OR 'intervertebral disc degeneration' OR 'intervertebral disc displacement' OR 'intervertebral disc chemolysis' OR 'lumbosacral region').

Inclusion criteria

The following inclusion criteria were applied to assess studies for inclusion in this review: (1) studies published in English, (2) randomized controlled trials (RCTs), (3) full-text availability, (4) diagnosis of lumbar disc herniation (LDH) without prior surgical intervention, and (5) ability to perform exercise.

The reviewers reached a decision on study inclusion during a consensus meeting.

Exclusion criteria

Trials that did not meet all five inclusion criteria were excluded. Additionally, reviews, meta-analyses, editorials, and case reports/case series were not considered for inclusion.

Study selection

Two researchers independently searched the databases using predefined keywords. In the first step, articles retrieved from the database searches were imported into the EndNote program. In the second step, abstracts, titles, and inclusion/exclusion criteria were screened. In the final step, the full texts of the remaining articles were reviewed, and relevant studies were included in the systematic review.

Data items and evaluation methods

The primary outcome measures in the trials were pain and functional disability. Pain was assessed using the VAS, NRS, DPQ, and NPRS questionnaires. Functional disability was evaluated using the ODI and RMDQ questionnaires.

Quality of life (QoL), transversus abdominis (TrA) activity capacity, and other assessments were considered secondary outcome measures. QoL was measured using the SF-36 questionnaire, while TrA capacity was assessed using the Pressure Biofeedback Unit (PBU).

Assessment of methodological quality

The Jowell and Navarro-Rubio rating system was used to assess the methodological quality. The quality of the analyzed studies ranged from good to fair. Level II studies classified as good were randomized controlled trials (RCTs) with large sample sizes, while level III studies classified as good to fair were RCTs with small sample sizes.

The study design classification used to evaluate the methodological quality of different articles was developed by Jovell and Navarro-Rubio (Table 1) [14]. A meta-analysis was not feasible due to the heterogeneity and inadequacy of the studies concerning their settings, exercise interventions, and outcome measures.

The authors screened the articles for content (e.g., sample size, age), group characteristics, inclusion criteria, interventions (e.g., types of exercise), outcome assessment parameters, and main results.

Table 1 Methodological classification of articles according to Jowell and Navarro-Rubio

Studies	Methodological quality	Strength of evidence
Ali et al. (2022)	Level II	Good
Chang et al. (2022)	Level III	Good to fair
França et al. (2019)	Level III	Good to fair
Hossain et al. (2021)	Level II	Good
Jamil et al. (2023)	Level II	Good
Manzano et al. (2020)	Level III	Good to fair
Ramos et al. (2018)	Level III	Good to fair
Sany et al. (2021)	Level II	Good
Taşpınar et al. (2023)	Level II	Good
Yildirim and Gultekin (2022)	Level III	Good to fair
Zhang et al. (2019)	Level II	Good
Zhou et al. (2022)	Level II	Good

Results

Study selection

The PRISMA flowchart in Fig. 1 shows the selection of studies. An initial literature search identified 1277 studies. Of these studies, 400 articles were eliminated as duplicates. Of the remaining 877 articles, 60 were excluded because they were systematic reviews, meta-analyses, observational studies, cohort studies or case-control studies. Of the remaining 817 articles, 805 were excluded because of mismatch of title, content and abstract ($n=561$), pre- and post-operative studies ($n=151$), no full text ($n=93$). As a result, twelve articles that met the criteria were analysed for systematic review.

Study characteristics

Reviews of the types of exercises performed in LDH are shown in the Table 2. Different types of exercise were favoured in the trials and these exercises are summarized as follows: Core stabilization exercises (CSE) + traditional physiotherapy [15], home-based therapeutic exercises [16], Richardson and Hides protocol exercises [17], McKenzie manipulative therapy [18], conventional treatment + CSE [19], motor control exercise(MCE) + sciatic nerve neurodynamic slider [20], exercises focused on the transversus abdominis and lumbar multifidus muscles [21], back and hip strengthening exercises [22], clinical pilates exercises [23], yoga exercises [24], isokinetic trunk muscle strength training [25] and traditional Chinese exercises and massage [26].

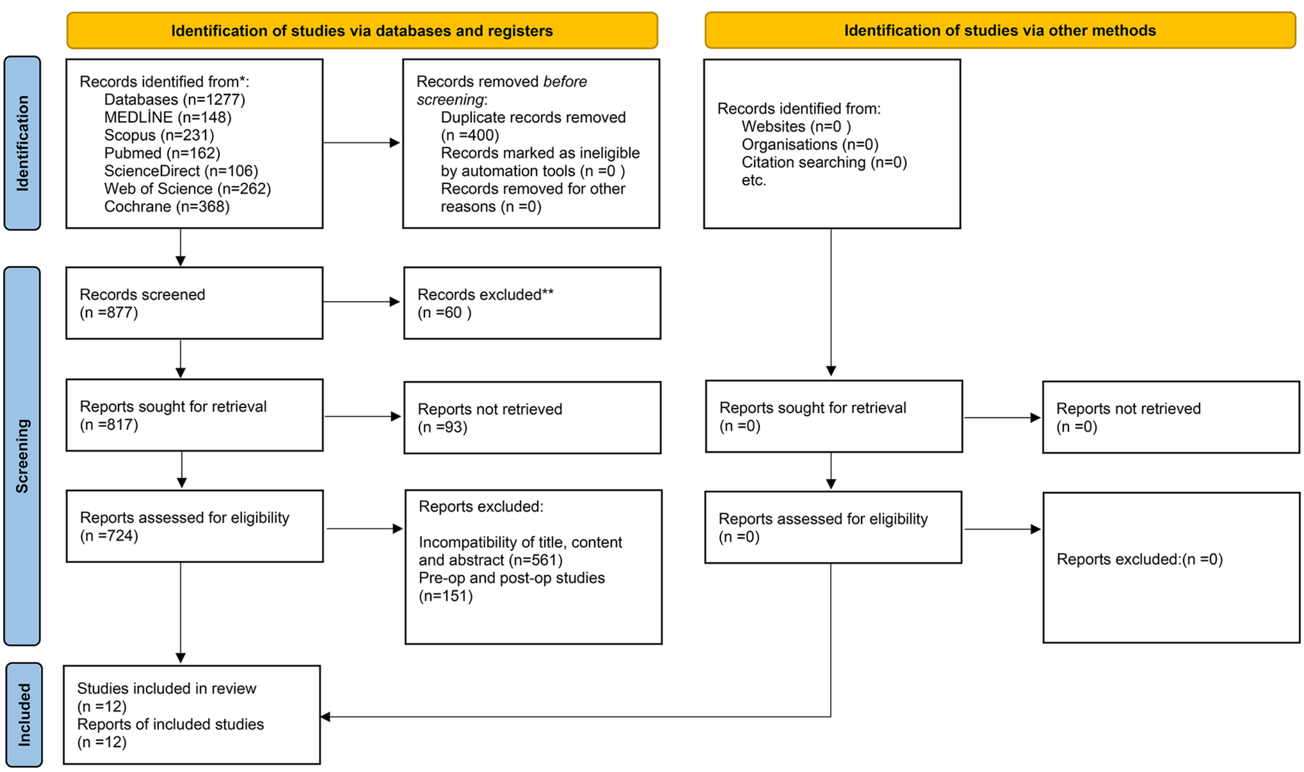

Fig. 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. Source: Page MJ, et al. BMJ 2021;372:n71. doi:10.1136/bmj.n71

Table 2 Participants and characteristics of the twelve included studies

Studies	Subject (n) Gender (F/M)	Age (years)	Exclusion criteria	Intervention Treatment session	Outcome measures	Main results	Funding sources and adverse events
Ali et al. (2022)	Study group ($n=48$) 27 F/21 M Control group ($n=49$) 25 F/ 24 M	Study group = 40.52 ± 4.6 Control group = 40.85 ± 4.9	1) Involved herniated lumbar disc or central canal stenosis, history of spinal surgery 2) Current medical treatment or physical therapy for chronic LBP	Study group = Core stabilization exercises+ Traditional physiotherapy Control group = Traditional physiotherapy 3 sessions/week, 12 weeks	Pain intensity (VAS) Disability (ODI) Lumbar lordotic angle (OmniDiagnost Eleva)	Core stabilisation exercises may affect pain intensity and functional abilities and therefore may be preferred in lumbar disc degeneration	Funding not reported Adverse event not reported
Chang et al. (2022)	QR code group ($n=20$) 10 F/10 M Control group ($n=20$) 9 F/11 M	QR code group = 58.3 ± 14.3 Control group = 60.6 ± 12.3	1) Psychological disorders 2) Cognitive deficits	QR code group = Home-based therapeutic exercises Control group = Therapeutic exercise without QR code Each exercise step was conducted with 3 sets of 10 repetition a day	Pain intensity (NRS) Disability (ODI)	QR codes have been found to be useful in encouraging patients to perform home-based therapeutic exercises	The present study was supported by a National Research Foundation of Korea grant funded by the Korean government (grant no. NRF-2019M3E5D1A02069399 and NRF2021R1A2C1013073) Adverse event not reported
França et al. (2019)	Motor control training group ($n=20$) 12 F/ 8 M Transcutaneous electrical nerve stimulation group ($n=20$) 13 F/ 7 M	MCT group = 43.1 ± 8.7 TENS group = 46.8 ± 7.7	1) Previous lumbar surgery 2) Carcinoma 3) Rheumatological diseases	MCTG = Richardson and Hides protocol exercises TENS group = TENS with 20 Hz frequency 2 sessions/week, 8 weeks	Pain intensity (VAS, McGill Pain Questionnaire) Disability (ODI) TrA activation capacity (PBU)	MCT is more effective than TENS in reducing pain, improving functionality and enhancing muscle activation	This study received public financial support from the: State of São Paulo Research Foundation (FAPESP) Adverse event not reported
Hossain et al. (2021)	Experimental group ($n=34$) 13 F/21 M Control group ($n=34$) 10 F/24 M	Experimental group = 38.59 ± 10.89 Control group = 37.71 ± 8.80	1) Any history of surgery for LDH 2) Comorbidity associated with endocrine disease, osteopenia, infection or carcinoma 3) History of fracture in the spine, ribs, or upper limb within last 1 year 4) Pre-existing phobia to physiotherapy or manipulative therapy	Experimental group = McKenzie manipulativetherapy Control group = Manual passive stretching Graded oscillatory mobilization in Maitland concept or static segmental mobilizations in Maitland concept 3 sessions/week, 4 weeks	Pain intensity (DPQ) Functional activities (FABQ and SBS) Disability (ODI)	The McKenzie method may be more effective with standard physiotherapy protocol for LDH	Funding: None Adverse event not reported

Table 2 (continued)

Studies	Subject (n) Gender (F/M)	Age (years)	Exclusion criteria	Intervention Treatment session	Outcome measures	Main results	Funding sources and adverse events
Jamil et al. (2023)	Group A = 26 Group B = 26	Group A = 35.53 ± 6.68 Group B = 36.00 ± 6.94	1) Recent surgery 2) Inflammatory arthritis 3) Cauda equina syndrome 4) Spinal tumor	Group A = Conventional Treatment + core stabilization Group B = Conventional Treatment 3 sessions/week, 24 weeks	Abdominal endurance (Trunk Flexion Test) Muscle endurance of spine (Modified Biering-Sorensen Test) Disability (ODI) Pain intensity (NPRS)	Core stabilization exercises are more effective than conventional treatment in improving patient functionality and reducing pain in lumbar disc herniation	Funding not reported Adverse event not reported
Manzano et al. (2020)	Neurodynamic mobilization + motor control exercises group (n = 16) 8 F/ 8 M Motor control exercises group (n = 16) 8 F/ 8 M	Neurodynamic + motor control group = 47.0 ± 8.0 Motor control group = 45.5 ± 6.0	1) Indication for surgical intervention, for example, absence of reflexes, muscle atrophy, and signs compatible with lumbar myelopathy 2) Had a confirmed disc herniation at other lumbar levels 3) Have had any other spinal conditions such as spinal tumors, spondylolisthesis, or cauda equina 4) Had received treatment for this condition by a physical therapist the previous 6 month 5) Pregnancy	Neurodynamic + motor control group = Motor control exercise + sciatic nerve neurodynamic slider Motor control group = Motor control exercise 8 sessions	Pain intensity (NPRS, S-LANSS) Disability (RMDQ) Sciatic nerve sensivity (The straight leg raise test) Pressure pain sensitivity (Pressure pain thresholds)	Neurodynamic mobilisation treatment combined with motor control exercises did not result in further improvement in pain, function or pressure pain thresholds	No funds were received for this study Adverse event was defined as sequelae of 1-week duration with symptoms perceived as distressing and unacceptable to the patient and required further treatment
Ramos et al. (2018)	Segmental Stabilization (SS) group (n = 15) 7 F/ 8 M TENS group (n = 14) 7 F/ 7 M	SS group = 40.9 ± 5.57 TENS group = 43.3 ± 5.98	1) Previous lumbar surgery 2) Carcinoma 3) Rheumatologic diseases 4) Patients involved in sports or load training for the spine over the 3 months prior to beginning treatment 5) Other causes of back pain, spinal stenosis, or lumbar spondylolisthesis	SS group = Exercises focused on the transversus abdominis and lumbar multifidus muscles TENS group = 60 min, with a frequency of 20 Hz 2 sessions/week, 8 weeks	Lumbar multifidus fatigue (EMG and The Sorensen test) TrA Activation Capacity (PBU) Pain intensity (VAS) Disability (ODI)	TENS reduced pain, had no effect on other results, but stabilization exercises improved all results	This study received public financial support from the Coordination of Improvement of Higher Education Personneland the State of São Paulo Research Foundation Any adverse event

Table 2 (continued)

Studies	Subject (n) Gender (F/M)	Age (years)	Exclusion criteria	Intervention Treatment session	Outcome measures	Main results	Funding sources and adverse events
Sany et al. (2021)	Intervention group (IG) (n=35) Control group (CG) (n=35)	IG=42.37 ± 10.32 CG=38.94 ± 8.33	1) Pregnancy 2) Cauda equina syndrome and other pathological conditions of the spine	IG=Back and hip strengthening exercises 5 sessions/week, 6 weeks Control group=Naproxen (500 mg) and Baclofen (10 mg) tablet twice a day for 3 weeks Hot moist compression 5 sessions/week, 3 weeks Both groups received the following ADLIs at the time of the intervention and for at least three months after the intervention	Pain intensity (VAS) Sciatica assessment (Range of hip straight leg raising test)	Strengthening exercises and instructions for activities of daily living increase CLBP due to LDH	Funding not reported Adverse event not reported
Taşpınar et al. (2023)	Clinical Pilates exercises group (CPE=27) 13 F/14 M Control group (n=27) 17 F / 10 M	CPE=50.3 ± 6.7 Control=50.1 ± 6.5	Those who did not meet the inclusion criteria were excluded	Clinical Pilates exercises group=CPE sessions Control group=Daily routines 3 sessions/week, 6 weeks	Pain intensity(VAS) Disability(ODI) Quality of Life(SF-36) Spinal mobility (Finger-to-floor test) Trunk flexors strength (Sit-and-reach tests) Lateral core muscles static endurance (Side bridge test)	CPE training is effective in reducing pain and disability and improving quality of life in patients with LDH	Funding not reported Adverse event not reported
Yildirim and Gultekin (2022)	Yoga group (n=24) 24 F Control group (n=24) 24 F	Yoga group=37.75 ± 6.03 Control group= 38.21 ± 7.87	1) Had progressive neurologic deficits or cauda equina syndrome 2) Have an unstable medical conditions that precludes exercise 3) Have sequestrated disc herniation 4) Have acute and/or subacute LBP 5) Have undergone prior lumbar surgery and/or epidural steroid injection 6) Have spinal deformities, such as spondylolisthesis and scoliosis 7) Had previous nerve injuries/operation at the lower extremities 8) Had any other conditions that cause of lower extremity neuropathy (e.g., diabetes mellitus, neurological disorder) 9) Had ankylosing spondylitis	Yoga group=One hour twice weekly for 12 weeks + patient education Control group=Patient education 2 sessions/week, 12 weeks	Pain intensity (VAS, McGill Pain Questionnaire, McLikert scale) Neuropathic pain and the treatment response (Douleur Neuropathique 4 scale, LANSS) Disability (ODI) Lumbar mobility (Modified Schober method) Hamstring muscle length (Passive knee extension)	Yoga treatment for neuropathic pain due to LDH was found promising	Funding not reported Adverse event not reported

Table 2 (continued)

Studies	Subject (*n*) Gender (F/M)	Age (years)	Exclusion criteria	Intervention Treatment session	Outcome measures	Main results	Funding sources and adverse events
Zhang et al. (2019)	Treatment group (n=40) 23 F / 17 M Control group (n=40) 22 F /18 M	Treatment group = 43.15 ± 9.64 Control group = 41.93 ± 8.98	1) Patients having a history of lumbar injury, fracture and dislocation, or surgery 2) Patients suffering from severe stenosis, spondylolisthesis and herniation of nucleus pulposus, or severe cauda equina syndrome 3) Patients suffering from purulent inflammation in the lumbar region, tuberculosis, tumor, spinal deformity, congenital dysplasia, severe pain of soft tissue, and so forth 4) Patients with a disease of the cardiovascular system, liver, kidneys, and blood, immune system disorders, metabolic diseases, and cognitive dysfunction	Treatment group= Routine rehabilitation treatment + isokinetic trunk muscle strength training Control group = Routine rehabilitation treatment + core muscle training 5 sessions/week, 8 weeks	Muscle strength + lumbar proprioception (Biodex Corporation) Disability (ODI) Pain intensity (VAS, JOA)	Isokinetic trunk muscle training not only increased muscle strength but also increased proprioception	Funding not reported Adverse event not reported
Zhou et al. (2022)	Experimental group (n=130) 66 F / 64 M Control group (n=129) 71 F / 58 M	Experimental group = 44.36 ± 10.44 Control group = 51.77 ± 10.32	1) History of severe spinal trauma pathology such as spinal bone tumor, tuberculosis, osteoporosis, spondylolisthesis and compression fracture 2) Had previous spinal surgery due to neurological deficits or cauda equine syndrome 3) Patients with serious diseases or mental illness such as cardiovascular, cerebrovascular, hematopoietic and digestive system 4) Had other autoimmune diseases, allergic diseases and acute and chronic infections 5) Pregnant women 6) MRI examinations should not be performed, such as those with pacemakers, neurostimulators, metal foreign bodies and insulin pumps 7) Participate in other clinical trials within 3 months	Experimental group = Traditional Chinese exercises + traditional Chinese massage Control group = Traditional Chinese massage group 3 sessions/week, 6 weeks	Pain intensity (VAS, Short Form Mc Gill Pain Questionnaire) Disability (ODI) Gait performances and lumbar spine activity (15 VICON Vero Cameras)	Combination therapy is more beneficial, combination therapy may be a valuable treatment option because it provides therapeutic benefits	This work was supported by the project of Shanghai Shenkang Hospital Development Center (No. 16CR1023A), Shanghai Science and Technology Innovation Action Plan (21Y21920301), Shanghai Science and Technology Innovation Action Plan Phospherus Cultivation Project (22YF1449900), and Shanghai Pujiang Program (21PJD071) No serious adverse events were reported

BDI: Beck Depression Inventory, CLBP: Chronic Low Back Pain, CT: Computed Tomography, DPQ: Dallas Pain Questionnaire, EMG: Electromyography, F:Female, FABQ: Fear Avoidance Beliefs Questionnaire, JOA: Japanese Orthopedic Association, LANSS: Leeds Assessment of Neuropathic Symptoms and Signs, LBP: Low Back Pain, LDH: Lumbar Disc Herniation, M:Male, MRI: Magnetic Resonance Imaging, NPRS: Numeric Pain Rating Scale, NRS: Numeric Rating Scale, ODI: Oswestry Disability Index, PBU: Pressure Biofeedback Unit, RMDQ: Roland-Morris Disability Questionnaire, SBS: Sciatica Bothersome Scale, SF-36: The Short Form-36, S-LANSS: Self-report Leeds Assessment of Neuropathic Symptoms and Signs Scale, TENS: Transcutaneous Electrical Nerve Stimulation, VAS: Visual Analogue Scale

Outcome measurements

Pain assessment

The studies assessed pain using a variety of methods including VAS, McGill Pain Questionnaire, The Short Form McGill Pain Questionnaire, DPQ, NPRS and NRS. In eight of the twelve studies pain was assessed by VAS, in three of these eight studies pain was assessed by VAS and McGill Pain Questionnaire together [17, 24, 27], Yildirim also used DN4 [24], in the remaining three studies pain was assessed by Chang NRS [28], Hossain DPQ [29], Jamil [19] and Manzano NPRS [20].

Functional assessment

The level of functional disability was assessed in ten of the twelve studies, using the ODI; Manzano used a different scale in his study, the RMDQ [20], and Sany did not include an assessment of this parameter in his study [22].

Transversus abdominis (TrA) activation

França and Ramos assessed TrA activation capacity using a pressure biofeedback unit (PBU) [17, 21].

Quality of life assessment

QoL was only assessed by Taşpınar et al., in this study it was assessed using the SF-36 [23].

Other assessments

The trials also included other, less common methods of assessment. These assessments were made by Ali et al., in their study, the lumbar lordosis angle was assessed using the OmniDiagnost Eleva device [15], Hossain et al. assessed participation in functional activities using the Fear Avoidance Beliefs Questionnaire(FABQ) and the Sciatica Discomfort Scale(SBS) [18]. The study by Jamil et al. assessed spinal muscle endurance using the modified Biering-Sorensen test and abdominal muscle endurance using the trunk test.

Ramos et al. evaluated electromyography (EMG) for LM muscle fatigue, EMG and Sorensen exercise test for lumbar multifidus fatigue [20]. Sany et al. the used the VAS and the straight leg raising test to assess the intensity of back pain based on clinical assessment [22].

Taşpınar et al. spinal flexibility and mobility were assessed by finger-to-floor distance and sit-and-reach tests, and lateral core muscle endurance by side bridge and trunk flexor dynamic endurance by sit-up repetitions [23]. Yildirim and Gultekin used the Leeds Assessment of Neuropathic Symptoms and Signs scale and assessed lumbar mobility with the modified Schober test and hamstring length with the passive knee extension test [24]. Zhang et al. used the American Biodex Isokinetic Trunk Muscle Strength Training Evaluation System to assess muscle strength and evaluate lumbar proprioception, and VAS, ODI and JOA to assess functional improvement in patients [25]. The study by Zhou et al. used gait analysis and 3D kinematics data for lumbar spine activity using 15 VICON Vero cameras [26].

Effect size

Effect sizes were calculated using the G*Power 3.1 software based on the data obtained from the study. The effect sizes related to pain and functional disability are presented in Table 3.

Table 3 Effect size comparison between groups before and after treatment

Studies	Pain Study Group Cohen's d	Pain Control Group Cohen's d	Functional Disability Study Group Cohen's d	Functional Disability Control Group Cohen's d
Ali et al. (2022)	3.857464	2.207814	5.926422	3.767638
Chang et al. (2022)	0.571429	0.285714	0.346128	0.125
França et al. (2019)	4.083333	0.681115	2.245618	0.284872
Hossain et al. (2021)	2.871317	1.262668	3.932588	1.323311
Jamil et al. (2023)	4.513043	2.309735	4.828595	1.730861
Manzano et al. (2020)	2.981997	2.209268	4.257601	2.123619
Ramos et al. (2018)	3.004549	0.606339	3.680789	0.300028
Sany et al. (2021)	6.201942	6.754251	-	-
Taşpınar et al. (2023)	1.526699	0.22306	2.974015	0.840706
Yildirim and Gultekin (2022)	0.145133	0.103983	0.037072	0.279092
Zhang et al. (2019)	4.123381	2.036667	7.122568	2.480581
Zhou et al. (2022)	2.529313	2.049827	2.266063	1.525477

Quality of evidence

After the results were pooled, the overall quality of evidence(QoE) for each outcome was graded using the PEDro scale [27]. The evidence was graded by two researchers through discussion and consensus. The Pedro scale provides 3 levels of QoE assessment for RCTs. Systematic review authors may classify the evidence as low, fair or high quality evidence depending on their assessment of the QoE for each outcome according to 11 key domains: (1) eligibility criteria were specified, (2) subjects were randomly allocated to groups (in a crossover trial, subjects were randomly allocated to receive treatments), (3) allocation was concealed, (4) the groups were similar at baseline with respect to key prognostic indicators, (5) all subjects were blinded, (6) all therapists administering the therapy were bilinded, (7) all assessors measuring at least one key outcome were blinded, (8) measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups, (9) all subjects for whom outcome measures were available received the treatment or control condition as allocated or, if this was not the case, data for at least one key outcome were analyzed by "intention to treat", (10) the results of statistical comparisons between groups are reported for at least one key outcome, (11) the trial provides both point measures and measures of variability for at least one key outcome. Two researchers graded the evidence by internal discussion and consensus.

Study risk of bias assessment

The first author extracted data from the analyzed trials and the second author reviewed the extracted data. Methodological quality was assessed by two reviewers who were blinded to each other. Both reviewers were trained to assess methodological quality. In case of disagreement between the two reviewers, the first author provided a third authoritative opinion.

Table 4 Change in pain according to VAS in intervention groups

Pre: 4.71 ± 1 [15]	Post: 1.73 ± 0.44 [15]
Pre: 6.4 ± 1.2 [17]	Post: 1.5 ± 1.2 [17]
Pre: 5.13 ± 1.30 [21]	Post: 1.40 ± 1.18 [21]
Pre: 7.20 ± 0.90 [22]	After 6 weeks: 1.03 ± 1.00 [22]
Rest: 2.21 ± 1.42 [23] General pain: 3.39 ± 1.29 [23] Pain during movement: 4.01 ± 1.43 [23]	Post rest: 0.55 ± 0.59 [23] Post general pain: 1.29 ± 0.62 [23] Post pain during movement: 1.81 ± 1.03 [23]
Pre: 5.70 ± 1.73 [24]	Post: 1.99 ± 1.64 [24]
Pre: 6.45 ± 0.96 [25]	Post: 2.88 ± 0.76 [25]
Pre: 51.77 ± 10.32 [26]	Post: 24.65 ± 11.11 [26]

Pain assessment

The change in pain according to VAS in the intervention groups is shown in Table 4. In the study where change in pain was analysed by NRS, change in pain was LBP (baseline: 2.6 ± 0.7, 2-month follow-up: 2.2 ± 0.7) and leg pain (baseline: 2.8 ± 0.6, 2-month follow-up: 2.5 ± 0.7) in the intervention group [16]. Pain was reported in the intervention group in the study analysing change in pain using the DPQ [18] (baseline: 3.77, 6-month follow-up: 1.30). Change in pain was reported as follows in the pain intervention groups in the studies analysed using the NPRS (7.12 ± 1.15) [19], baseline: 5.9 ± 1.4, after 8 sessions: 2.5 ± 0.8) [20].

Functional assessment

The change in the level of functional disability in the intervention groups was as follows: (pre: 35.64 ± 3.05, post: 18.57 ± 2.7) [15], (baseline: 13.9 ± 1.7, 2-month follow-up: 13.2 ± 2.3) [16], (pre: 12.3 ± 3.4, post: 5.1 ± 3.0) [17], (baseline: 32.77, 6-month follow-up: 8.00) [18], (53.54 ± 10.96) [19], (pre: 14.8 ± 2.42 post: 5.8 ± 2.47) [21], (pre: 29.07 ± 6.24 post: 15.07 ± 2.32) [23], (baseline: 40.46 ± 17.61, 1-month follow-up: 35.52 ± 17.79, 3-month follow-up: 19.58 ± 8.84, 6-month follow-up: 18.46 ± 6.28) [24], (pre: 27.06 ± 2.94, post: 10.55 ± 1.45) [25], (pre: 27.44 ± 6.33, post: 14.93 ± 4.57) [26]. A change in functional disability as assessed by the RMDQ was found in the intervention group (baseline: 12.0 ± 1.1; 2 months: 6.5 ± 1.6) [20].

Transversus abdominis (TrA) activation

In the study by França et al. in the MCE group (pre: −1.1 ± 1.3, post: −3.2 ± 1.0), in the TENS group (pre: −1.2 ± 0.7, post: −1.7 ± 0.9), in the study by Ramos et al. in the segmental stabilisation group (pre: −1.13 ± 0.51, post: −3.73 ± 0.86) and in the TENS group (pre: −1.50 ± 0.65, post: −1.71 ± 0.84) [17, 21].

Other assessments

In the study by Manzano et al., the neuropathic symptom score (S LANSS) of the motor control and neurodynamic mobilization group (baseline: 12.0 ± 1.1, 2-month follow-up: 6.5 ± 1.6), straight leg raising degree (baseline: 55.2 ± 6.5, 2-month follow-up: 71.9 ± 9.8), pressure pain threshold tibial nerve kg/cm² (baseline: 3.2 ± 0.6, 2 month follow up: 4.0 ± 0.8), pressure pain threshold common peroneal nerve kg/cm² (baseline: 2.1 ± 0.9, 2 month follow up: 2.8 ± 0.5) but were probably not clinically significant [20]. According to Ramos's study, Lumbar multifidus fatigue frequency SS group pre-treatment(initial: 163.3 ± 155.8, final: 153.5 ± 148.5), SS group post-treatment (initial: 171.2 ± 166.9, final: 167.5 ± 162.8) TENS group mean LM fatigue frequency pre-treatment (initial: 148.8 ± 12.1, final: 145.1 ± 10.7), post-treatment (initial: 156.5 ± 13.3, final: 150.7 ± 12.06), segmental stabilization is more effective than TENS treatment in reducing fatigue [21]. In the study by Sany et al., sciatic nerve, hip and back strengthening exercises resulted in a straight leg raising angle on the affected leg (baseline: 48.29 ± 12.30, after 6 weeks: 80.57 ± 8.47) and on the unaffected leg (baseline: 72.57 ± 15.69, after 6 weeks: 86.71 ± 6.30) and a greater increase in blood pressure than medical treatment [22].

Quality of evidence

According to the PEDro scale, the overall average score of the studies was 6.75 (minimum: 5, maximum: 9 points) (Table 5).

Discussion

This systematic review evaluated the scientific literature on the effectiveness of exercise in individuals with lumbar disc herniation (LDH). The literature indicates that exercise is beneficial for people with LDH; however, there is no consensus on the most effective type of exercise. The effect sizes of the studies were examined, and analysis revealed that, in terms of pain and functional disability, the majority of the studies had strong effect sizes, while some demonstrated moderate effect sizes.

Regular physical activity is believed to have a protective effect against peripheral damage by modulating central pain inhibitory pathways and the immune system. It has been suggested that, under resting conditions, the brainstem exhibits lower opioid tone and overall reduced inhibition. Consequently, neurons demonstrate greater facilitation in response to nociceptive input, accompanied by increased phosphorylation of the NR1 subunit of the NMDA receptor and elevated expression of the serotonin transporter (SERT).

Furthermore, regular physical activity is proposed to enhance the release of endogenous opioids in the brainstem, which inhibit facilitatory neurons and reduce pain facilitation. This mechanism is associated with decreased phosphorylation of the NR1 subunit of the NMDA receptor and reduced SERT expression. Overall, a physically active state is characterized by enhanced opioid and serotonin-mediated inhibition and diminished excitatory signaling [28].

Regular physical activity is known to regulate the immune system both locally at the site of injury and systemically, including within the central nervous system. In

Table 5 PEDro scale

Study criteria	Ali et al. (2022)	Chang et al. (2022)	França et al. (2019)	Hossain et al. (2021)	Jamil et al. (2023)	Manzano et al. (2020)	Ramos et al. (2018)	Sany et al. (2021)	Taşpınar et al. (2023)	Yildirim and Gultekin (2022)	Zhang et al. (2019)	Zhou et al. (2022)
Eligibility criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Random allocation	1	1	1	1	1	1	1	1	1	1	1	1
Concealed allocation	0	1	1	1	0	1	0	0	0	0	0	0
Baseline comparability	1	1	1	1	1	1	1	1	1	1	1	1
Blinded participants	0	0	0	0	0	1	0	0	0	0	0	0
Blinded therapists	0	0	0	0	0	1	0	0	0	0	0	0
Blinded assessors	1	1	1	1		0	1	1	0	1	1	1
Adequate follow up	0	1	0	1	1	1	0	1	0	1	0	0
Intention-to-treat analysis	1	1	1	1	1	1	1	1	1	1	1	1
Between-group comprasions	1	1	1	1	1	1	1	1	1	1	1	1
Point estimates and variability	1	1	1	1	1	1	1	1	1	1	1	1
Total PEDro scale	6	8	7	8	6	9	6	7	5	7	6	6
Sample size ≥ 50	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes
PEDro classification	Good	Good	Good	Good	Good	Excellent	Good	Good	Fair	Good	Good	Good

a physically inactive state, there is an increased presence of pro-inflammatory cytokines and a reduced presence of anti-inflammatory cytokines. However, with regular physical activity, this balance shifts towards a higher concentration of anti-inflammatory cytokines and a lower concentration of inflammatory cytokines. Inflammatory cytokines activate receptors on nociceptors, leading to pain, whereas anti-inflammatory cytokines inhibit nociceptor activity, thereby preventing pain. Macrophages, which are present in muscle tissue, secrete either inflammatory or anti-inflammatory cytokines depending on their phenotype. Classically activated (M1) macrophages primarily secrete inflammatory cytokines, while regulatory (M2) macrophages secrete anti-inflammatory cytokines.

In a state of inactivity, M1 macrophages are predominant compared to M2 macrophages. However, during physical activity, this balance shifts in favor of M2 macrophages. The analgesic effects of regular physical activity and exercise are inhibited when IL-10 (associated with muscle damage) or IL-4 (associated with nerve damage) is blocked. Therefore, at the site of peripheral injury, macrophage phenotype alterations contribute to the analgesic effects induced by regular exercise [29]. In the included trials, no clear information on cost-effectiveness was available. However, the home-based exercise program utilizing QR codes demonstrated a higher level of evidence compared to other trials and was found to be effective. The fact that this benefit was achieved through a home-based exercise program suggests that it may offer advantages over other interventions [16].

Exercise therapy may be a preferred option for individuals with low back pain, lumbar disc herniation, lumbar spinal stenosis, low back and leg pain, prolapsed lumbar disc (PLID), lumbar radiculopathy, and other chronic pain conditions. No adverse events were reported in the trials; however, some studies noted that participants experienced symptoms during exercise. In another trial involving yoga, participants were advised to stop or modify their exercise routine if pain developed or increased [24].

Summarizing the limitations of the reviewed trials, the results cannot be generalized due to the small sample size, the lack of blinding of the therapist administering the treatment, the potential risk of bias when the same person performs the assessment, the absence of follow-up to determine long-term effects and symptom recurrence, and the lack of comparison between home-based and hospital-based exercise programs.

Additional limitations include inadequate exercise compliance and daily follow-up of patients, insufficient information provided to the control group regarding exercise, and the absence of blinding in some trials. Furthermore, adequate follow-up was not feasible due to the lack of long-term follow-up, and gait analysis could not be conducted in certain centers due to insufficient biomechanical equipment [15–26].

Each exercise analyzed in the trials involved different treatment durations and session frequencies. Since exercises were assigned to different groups, there was no standardized number of sessions. The trials included a minimum of 8 sessions and a maximum of 40 sessions, with each type of treatment demonstrating benefits for patients. For example, a core stabilization program conducted three days per week was found to be effective, with patients experiencing benefits after four weeks, attending 2–3 sessions per week. All trials included in the review demonstrated a high level of evidence. In total, twelve articles meeting the inclusion criteria were analyzed [15–26].

Pain

In this systematic review, it was found that pain in people with LDH was assessed using a variety of different assessment methods in order to evaluate the effectiveness of the intervention and pain relief has been the result in all studies [9–20]. The core stabilisation and traditional physiotherapy program used by Ali et al. was effective in reducing pain [15]. Chang et al. used the NRS to assess pain in people who participated in a QR code home-based therapeutic exercise program and showed that there were changes in LBP and leg pain. QR code home-based therapeutic exercise was effective in reducing LBP and leg pain [16]. In the study by França et al., the MCE group showed greater pain reduction than the TENS group; MCEs may be preferred for pain reduction. The change in pain rating in the MCE group was demonstrated by VAS and the McGill Pain Questionnaire [17]. The reduction in pain in the McKenzie manipulative therapy group was greater in the long term, the control group received mobilisation and static stretching, McKenzie manipulative therapy was more effective than static stretching and mobilisation, this is a high-quality study and McKenzie manipulative therapy is applicable to patients [18]. Jamil et al. in his study, the mean pain score between groups was expressed using the NPRS, no significant difference was found between groups, but the study results reported that CSEs reduced pain [19]. Ali and Jamil used similar treatment methods in their studies, but Ali reported a statistically significant reduction in pain in his study, while Jamil reported a reduction in pain in his study, but there was no difference between the groups in terms of pain reduction, which may be due to differences such as different methods of pain assessment (Ali: VAS, Jamil: NRPS), different number of participants (Ali:97, Jamil:52), different duration of treatment (Ali:12 weeks, Jamil:8 weeks). In the study by Manzano et al., pain intensity in NRPS was initially similar between the motor control and neurodynamic mobilisation and motor control groups, but after two months of follow-up, pain decreased more in the neurodynamic mobilisation and motor control groups [20]. When considering the QoE of the studies, the studies by Chang and Manzano are the highest rated studies and in these two studies, which are similar in terms of methodological quality, pain assessment was performed at similar times in terms of follow-up time, but the change in pain was greater in Manzano's study, this difference may be due to the different assessment methods or neurodynamic mobilisation and MCEs may be more effective in reducing pain than home-based therapeutic exercises [16, 20]. The addition of neurodynamic mobilisation to the MCE programme was reported to result in some reduction in neuropathic symptoms and mechanical sensitivity, which may have been a factor in the difference in pain change. Ramos et al. found VAS scores in the segmental stabilisation group and VAS scores in the TENS group, pain decreased in both groups but the decrease was greater in the segmental stabilisation group [21]. França and Ramos included TENS groups in their study, and both said that the exercises performed in the study groups were more beneficial in reducing pain than the TENS group [17, 21]. MCTG had optimal abdominal wall depression as measured by PBU, a greater reduction in functional disability scores and greater efficacy in pain relief, so there was more pain reduction than in the TENS group and it is possible that neurodynamic mobilization can alter diminished inhibitory pain mechanisms, alter blood flow to pain-related areas in the brain and reduce activation of supraspinal pain centers. Sany et al. in their study found the VAS score as a result of 6 weeks of back and hip strengthening exercises. This study compared medication with exercise and found that exercise was more effective than medication in reducing pain [22]. Taşpınar et al. as a result of the intervention, rest, general pain and pain during exercise were assessed before and after treatment in the Clinical Pilates exercise group, and since the reduction in pain was significantly higher than in the control group, Clinical Pilates exercises can be preferred for pain reduction [23]. The yoga intervention conducted by Yildirim and Gultekin differed from other studies in that it used multiple pain assessments together, and the yoga intervention was effective in reducing pain and maintained its effect at the three-month follow-up [24]. In the study by Zhou et al., the combined use of traditional Chinese exercise and massage was found to be more effective in reducing pain than traditional Chinese massage [26]. Although all the methods used in the studies were effective in reducing pain, the studies by Manzano [20] and Chang [16] were found to be better in terms of QoE and methodological quality. Trials of CSE and segmental stabilisation exercises were found to be effective in reducing pain, and the trials were of high quality. One trial included only medication as a control and found exercise to be more effective, the quality of the trial was high, further trials comparing the effects of exercise and medication on pain can be done to make this situation generalisable. Trials of clinical Pilates and yoga showed pain reduction and were of high quality. Isokinetic muscle-strength training and hip and back-strength training were also effective in reducing pain, and the quality of the trials was high. A study that combined traditional Chinese exercise and massage found it to be effective in reducing pain, and the quality of the studies was high. Neurodynamic mobilisation and motor control training and home-based therapeutic exercise applications with QR code application can be recommended from the literature for LDH patients. Exercise is more effective in reducing pain than electrotherapy, medical treatment, daily routines or patient education. Exercise therapy is effective in the management of LDH disease. Treatment alone is more effective if it is supported by an exercise approach. The exercise with the highest level of evidence for pain reduction is MCE, we think this may be because the addition of neurodynamic mobilisation to the MCE programme may have led to some reduction in neuropathic symptoms and mechanical sensitivity because that is how it was expressed in the trials.

Functional disability

In this systematic review, functional disability in people with LDH was assessed using the ODI in all but one study, and different approaches to exercise appeared to have good effects on functional disability.

In the study by Ali et al., which used CSE + traditional physiotherapy and a traditional physiotherapy program, functional disability was assessed using the ODI, and the ODI score decreased significantly in both groups compared with pretreatment, but the change was greater in the CSE group [15]. Chang et al. assessed functional disability with ODI in the QR-coded home-based therapeutic exercise approach and maintained its effect at 2-month follow-up, but the change in ODI in the group doing therapeutic exercise without QR code was not found to be significant, QR-coded home-based therapeutic exercise approach may be preferred to reduce the level of functional disability [16]. In the study by França et al., MCEs were found to be effective in reducing functional disability as measured by ODI scores, although functional disability decreased after treatment in the TENS group, but not significantly [17]. In the McKenzie manipulative treatment by Hossain et al., control functional disability was assessed using ODI scores. The use of McKenzie's manipulative therapy may be effective in improving functional disability in the long term, the study quality was high, it may be preferred in the treatment of patients [18]. In the study by Jamil et al., the level of functional disability of the CSE + traditional treatment group and the traditional treatment group was assessed using the ODI score. There was no difference between the two groups, but CSE was reported to reduce functional disability at the end of treatment [19]. In their study, Manzano et al. used the RMDQ to assess functional disability. However, the motor control group was more effective in reducing functional disability [20]. The level of functional disability in the segmental stabilisation and TENS groups was assessed using the ODI in the study by Ramos et al. In this study, functional disability was reduced in both groups, but there was a significant reduction only in the segmental stabilisation group [21]. The study by Taşpınar et al. found that clinical Pilates was effective in reducing functional disability [23]. Functional disability was assessed using the ODI in the yoga study by Yildirim and Gultekin and yoga is effective in reducing functional disability in the long term [24]. Zhang et al. assessed the effect of routine + isokinetic trunk muscle training and joint + core muscle training on functional disability using the ODI and showed that trunk muscle training using the isokinetic system was more successful in reducing functional disability than core muscle training [25]. In the study by Zhou et al., they used the ODI to evaluate the prolongation of traditional massage and traditional Chinese exercise and traditional Chinese massage on functional disability. They reported that traditional Chinese massage and exercise were more effective in reducing functional disability [26]. The quality of all the trials reviewed was high and all were found to be beneficial in reducing functional disability, but some trials used similar treatment modalities, for example Ali and Jamil used similar treatment modalities, but Ali achieved a greater improvement in ODI scores; this may be due to differences in the number of participants in the study and the duration of treatment. Exercise was found to be effective in reducing functional disability in all the trials, but yoga exercise was found to be more effective than others in reducing functional disability in the long term. People with LDH may get better function in the long term with yoga interventions. Yoga exercise provided more functional improvement in the long term than other types of exercise. The exercise with the highest level of evidence for disability is the MCE; this is because the addition of neurodynamic mobilisations to the MCE programme results in the dissipation of intraneural fluid and we believe that this may help to reduce intraneural oedema in people with neural compression and contribute to functionality, because this is how it has been expressed in studies.

Transversus abdominis (TrA) activation capacity

The current review found that segmental stabilisation exercises were more effective than MCEs in changing the ability to activate the TrA, and both studies were of high quality [17, 21]. This result is important in terms of consensus, but generalisation may not be possible due to the fact that there are two studies, so studies with similar results may be needed.

Quality of life

In the study by Taşpınar et al., it was found that the increase in the score of the sub-parameters of the SF-36 of the participants in the clinical pilates group was higher than in the control group, clinical pilates improved the QoL [23]. The study by Taşpınar et al. was of high quality, but it was the only study in this review that examined QoL and further studies are needed to generalise the results.

Other criteria for the evaluation

In this systematic review, which also looked at other parameters, all the studies included in the review had a high level of evidence or explained how the other parameters were looked at. In the study by Ali et al., CSE + conventional treatment was found to be more effective than conventional treatment in reducing the lumbar lordosis angle, and CSEs are useful in reducing the lumbar lordosis angle [15]. The study by Hossain et al. showed that there was no difference in fear-avoidance beliefs and functional activities on the FABQ and SBI [29]. The study by Jamil et al. used the trunk flexion endurance tests and the Biering-Sorensen test to check endurance. These tests are used to check the isometric resistance of the hip and back extensor muscles [19]. In the study by Manzano et al., the degree of straight leg raising was assessed by tibial nerve pressure kg/cm², peroneal nerve pressure kg/cm² and neuropathic symptom score (S LANSS) [20]. It produced a greater increase in blood pressure than medical treatment [22]. In the study by Taşpınar et al., the increase in the sit-and-reach test, finger-floor distance test, side-bridge test and sit-up test was significantly higher in the clinical Pilates group than in the control group [23]. In the yoga study by Yildirim and Gultekin, passive knee extension decreased, Schober increased, Douleur Neuropathic 4 decreased, LANSS decreased and yoga significantly improved these parameters [24]. In the study conducted by Zhang et al., they used VAS, ODI, JOA for muscle strength increase, lumbar proprioception and function assessment with the isokinetic system, and as a result, strength training with the isokinetic system was found to be more effective than CSE training in all parameters [25]. In the study by Zhou et al., 15 VICON Vero cameras were used to acquire 3D kinematic data for the SF-MPQ, which consists of the Pain Rating Index and gait performance and lumbar spine activity. Traditional Chinese massage and traditional Chinese exercise were found to reduce pain and improve walking performance [26].

Limitation

Due to variations in the methods used across trials, the results could have been more standardized if additional similar studies had been conducted.

The number of participants in the reviewed trials was limited, and small sample sizes may not be sufficient to generalize the findings. Additionally, some trials lacked follow-up, making the long-term effects of the methods found to be effective uncertain.

There was no standardization in the evaluation methods used across the trials. Furthermore, due to differences in age, sex, and treatment types among participants, each trial could only be evaluated individually.

Conclusion

There are two main types of treatment for LDH disease, conservative and surgical. This review looked at the effectiveness of exercise among conservative treatments. Twelve good-quality trials agree that exercise is useful for in reducing pain and functional disability in LDH. The trials analysed different types of exercise and reported that each type of exercise was beneficial in the groups that received it. Two studies, QR code home-based exercise application and neurodynamic mobilisation and MCEs, scored higher in terms of methodological quality and QoE than the other studies, we also believe that motor control and neurodynamic mobilisation exercises are effective. It is known that neurodynamic mobilisation results in the distribution of intraneural fluid, which can help to reduce intraneural oedema in people with neural compression, and that MCEs also help to improve function, and these two effects have been shown to have a positive impact on the results shown in the study.

Author contributions Authors SA and OU jointly developed the design and methods of the systematic review. SA conducted data collection and analysis, while OU assisted in literature review and interpretation of the results. All authors reviewed and approved the final manuscript. PROSPERO registration number was CRD42023485805.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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