SCOPING REVIEW

Physiotherapeutic and technological approaches to lumbar disc herniation per sustainable development goal 3: Scoping Review

Danyal Ahmad, Saima Riaz, Syeda Khadija Kazmi, Muhammad Naveed Babur

Abstract

Objective: To map current physiotherapeutic and technological interventions for lumbar disc herniation, and to evaluate their alignment with Sustainable Development Goal-3.

Method: The scoping review was conducted at Department of Allied Health The Superior University from January 2025 to June 2025 and comprised literature search on PubMed, Scopus, Physiotherapy Evidence Database, Cochrane Library, Directory of Open Access Journals, PakMediNet and Google Scholar databases for randomised controlled trials published between January 2015 and June 2025 about physiotherapeutic or technology-assisted interventions in lumbar disc herniation(LDH) patients which reported clinical outcomes. Data was extracted and subjected to narrative synthesis.

Results: Of the 78 studies assessed, 15(19.2%) randomised controlled trials (RCTs) including 1,261 participants aged 18–80 years were analysed. Physiotherapeutic interventions(n=10) including manual therapy, spinal mobilisation, McKenzie and motor control exercises, Pilates and combination approaches, demonstrated consistent improvements in pain, disability, functional outcomes and quality of life. Adjunctive modalities, such as bamboo-based medicinal moxibustion, traction with paraffinotherapy, and neurodynamic mobilisation further improved functional outcomes or neuropathic symptoms. Technology-assisted interventions(n=5) including non-surgical spinal decompression, portable lumbar exoskeletons, digital app-based physiotherapy, Quick Response code-guided exercise programmes and high-intensity laser therapy, produced comparable improvements to conventional physiotherapy, with additional benefits in treatment adherence and patient satisfaction.

Conclusion: Both conventional physiotherapy and selected technology-assisted interventions were associated with improvements in pain, disability and functional outcomes in lumbar disc herniation patients.

Key Words: Lumbar disc herniation, Physical therapy modalities, Rehabilitation, Pain, Telemedicine.

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Department of Allied Health Sciences, The superior University, Lahore, Pakistan.

Correspondence: Danyal Ahmad. **Email:** danyal03@hotmail.com

ORCID ID: 0000-0001-8614-4328

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Introduction

Low-back pain (LBP) ranks among the most common causes of global disability.[1] Symptomatic LDH affects roughly 1-3% of adults, most commonly aged 30-50 years. About 95% of LDHs occur at L4-L5 or L5-S1.[2]The socioeconomic impact is large: LBP (often discogenic) results in healthcare costs and lost productivity worth billions globally.[3]

Contemporary management of LDH emphasises non-surgical, physiotherapeutic strategies. Clinical guidelines recommend conservative care as first line, focussing on patient education, analgesics or anti-inflammatories, and structured exercise therapy. Common physiotherapy interventions include core-stabilisation and extension exercises, manual techniques and adjunct modalities, such as lumbar traction, neural mobilisation, taping and electrotherapy.[4] The combination of non-surgical treatment options, such as traction, manual therapy and exercises, aims at restoring lumbar mechanics, decompresses the nerve root, and strengthens supporting musculature.[5]

Emerging technologies in rehabilitation are further transforming LDH rehabilitation. Other innovations, such as virtual-reality (VR) rehabilitation systems and robotic-assisted training, are also being explored to make therapy more engaging and precise, although high-quality evidence in LDH is still emerging.[6] The United Nations Sustainable Development Goal-3 (SDG-3; Good Health and Wellbeing) focusses on ensuring healthy lives and promoting wellbeing through access to quality healthcare services. Non-surgical management through physiotherapy and technology-assisted interventions plays an important role in improving functional outcomes and accessibility to care.[7]

The current scoping review was planned to map recent physiotherapeutic and technological interventions for non-surgical management of LDH in relation to SDG-3, highlighting the relevance of evidence-based and sustainable rehabilitation strategies for musculoskeletal health.

Materials and Methods

The scoping review was conducted at Department of Allied Health the Superior University from January 2025 to June 2025 and comprised literature search on PubMed, Scopus, Physiotherapy Evidence Database (PEDro), Cochrane Library, Directory of Open Access Journals (DOAJ), PakMediNet and Google Scholar databases for studies published between January 2015 and June 2025. The review followed the Population-Intervention-Comparison-Outcome (PICO) framework.[8] Individuals with LDH were taken as the population, physiotherapy and technology-based procedures were the interventions, conventional or usual care provided the comparator, and pain, disability and function were the outcomes. LDH diagnosis was based on a combination of clinical features and diagnostic criteria reported in the included trials, including LBP with radiculopathy and imaging confirmation, predominantly magnetic resonance imaging (MRI).[9–11] The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines[12], and the protocol was registered on the Open Science Framework (OSF) (OSF Registration ID: 5ygrm) and is publicly accessible at https://osf.io/5ygrm/, prior to data extraction.[13]

The review comprised RCTs involving individuals with LDH regardless of age, gender or severity. The assessed physiotherapy interventions included exercise therapy, manual therapy, electrotherapy, education and rehabilitation, as well as technological advancements, like VR, robotics, wearable devices, tele-rehabilitation, and tools based on artificial intelligence (AI). The duration of interventions or the follow-up was not the deciding factor in the review. RCTs were included only if they reported clinical outcomes, such as pain reduction, functional improvement, quality of life (QOL), patient satisfaction, and return to work. Additionally, studies aligned with SDG-3 or related to equitable access to effective health interventions were considered. The studies excluded were those focussing solely on surgical or pharmacological interventions, lacking a physiotherapeutic or technological component. Also excluded were non-full-text articles, non-primary research, like editorials, commentaries and abstracts, and studies published in languages other than English.

The search strategy comprised key words and Boolean operators, such as: ("Lumbar Disc Radiculopathy" OR "LDH") AND ("Physiotherapy" OR "Rehabilitation" OR "Exercise Therapy") AND ("Technology" OR "Virtual Reality" OR "Tele-rehabilitation" OR "Wearables" OR "Robotics") AND ("Conservative Management") AND ("SDGs" OR "SDG-3" OR "Health Equity"). Filters for English language and human studies were applied where available, and reference lists of the included articles were also screened to capture additional relevant studies.

Data from the included studies was collected using a self-designed structured extraction form in Microsoft Excel 2016. The study characteristics noted included author, year, country, population, intervention, comparator and outcomes. Data extraction was conducted independently by two reviewers, and discrepancies, if any, were resolved through discussion or in consultation with a third reviewer. No major assumptions or data transformations were applied, and the data was extracted as reported in the original articles. The risk of bias of the RCTs was assessed using the Cochrane Risk of Bias 2 (RoB 2), which evaluated potential bias across five domains.[14]

Results

Of the 78 studies assessed, 15(19.2%) RCTs were analysed (Figure 1) which involved LDH patients aged 18-70 years. Interventions included physiotherapeutic approaches, technology-assisted therapies, combinations with exercises and advice. Study duration ranged from 10 days to 12 weeks, with follow-up periods extending up to 24 months. The sample sizes varied between 32 and 312 participants (Table). The methodological quality of the trials indicated that most studies had low risk in the domains of randomisation and outcome measurement, while some studies showed concerns related to deviations from intended interventions and missing outcome data (Figure 2).

Overall, 10(66.6%) studies evaluated conventional physiotherapy techniques, including manual therapy, spinal mobilisation, McKenzie exercises, Pilates and physiotherapy combination techniques (Table).[10,11,15–22] Spinal mobilisation with stabilisation exercises reduced anxiety, depression, kinesiophobia and pain.[10] McKenzie exercises and motor control exercises produced significant improvements in pain, disability and function over short- and long-term follow-ups.[11,16] Manual therapy combined with Dowling's progressive inhibition of neuromuscular structures (PINS) and spinal mobilisations with leg movement (SMWLM) techniques improved pain, activity limitation, sexual disability and psychosocial

Table: Summary of the studies reviewed (n=15).

Author, Year	Design	Sample,Age	Intervention	Comparator	Duration	Outcomes
Huang et al., 2025[23]	RCT	118 Age (20-70 years)	Portable lumbar exoskeleton: sitting traction (20 min), ROM exercises (6 directions × 20 reps), resistance training (2–10 kg, 4 sets) (n = 60)	Traditional supine traction (25–50% body weight), MT (joint mobilization, apex board), therapist-led resistance training.(n = 60)	10 sessions over 20 alternate days	No significant difference in pain; both groups improved in VAS, ODI, ROM. Exoskeleton treatment is non-inferior to traditional methods; safe and feasible for home/community rehab.
Danazumi et al., 2024[15]	Three arm parallel group RCT	54 Age (25–48 years)	Group 1 (n=18): Manual therapy Dowling's PINS and Mulligan's SMWLM techniques + sexual advice.	Group 2 (n=18) Manual therapy alone Group 3 (n=18) Exercise therapy alone	12 weeks (follow-up for 40 weeks)	Manual therapy combined with sexual advice led to clinically meaningful improvements in sexual disability, activity limitation, pain catastrophizing, and kinesiophobia compared with manual therapy alone or exercise therapy alone at long-term follow-up. No single optimal sexual position was identified for individuals with disc herniation-related pain.
Taşkaya et al., 2024[19]	RCT	32 Manual therapy group: 39.8 ± 9.5 years; Exercise group: 38.3 ± 9.2 years	Manual therapy group: Spinal mobilization (AP, rotational, flexion) + stabilization exercises(n=16)	Exercise group: Stabilization exercises + sham mobilization(n=16)	10 sessions over 5 weeks	Manual therapy had positive effects on psychological factors, including pain, kinesiophobia, pain catastrophizing, anxiety, depression, and QOL in patients with LDH.
Xue et al., 2024[20]	RCT	312 Age 21–65 years	Ma's bamboo-based medicinal moxibustion targetting specific acupoints n=156	Acupuncture Standardized acupoint needling n=156	12 sessions over 13 days (follow-up at 28 days)	Ma's bamboo-based medicinal moxibustion therapy was as effective as acupuncture in relieving low back pain in patients with LDH and showed additional benefits in improving lumbar function and daily living ability, making it a safe and effective alternative treatment for LDH.
Tache-Codreanu & Trăistaru, 2024[25]	RCT	133 Age: 58.85 ± 12.10 years	Group 1: High Intensity Laser + standard rehabilitation. (n=66)	Group 2: Standard rehabilitation only(n=67)	10 days	The group receiving a rehabilitation programme with integrated high-intensity laser therapy showed greater improvement in motor deficits, highlighting the positive effects of high-intensity laser therapy on functional outcomes in patients with LDH.

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Author, Year	Design	Sample,Age	Intervention	Comparator	Duration	Outcomes
Park et al., 2023 [24]	RCT	100 Age 18-53 years	Digital Application Physical Therapy using "Dr AI" smartphone app + 1 initial in-person session. (n=50)	Conventional Physical Therapy (n=50)	4 weeks (3x/week)	Digital application physical therapy was as effective as conventional physical therapy in improving structural and functional impairments, activity limitation, participation restriction, lower extremity strength, trunk mobility, activities of daily living, quality of life, and functional movement scores in patients with discogenic LBP.
Kilpikoski et al., 2023[11]	Multicentre, assessor-blinded, parallel-group RCT	66 Age 18–60 years	McKenzie Method: max 7 sessions with certified therapists + education book + home exercises(n=33)	Guideline-based advice: 1 physiotherapy session + booklet on self-management(n=33)	Up to 7 sessions over approx. 2–20 weeks	Multiple sessions of McKenzie-based back exercises combined with a McKenzie-specific patient educational book produced similar improvements in back and leg pain, disability, and health-related quality of life compared with guideline-based advice at long-term follow-up
Taşpınar et al., 2023[18]	RCT	54 Age 30-60 years	Clinical plates 3x/week for 6 weeks (core stability, flexibility, trunk endurance exercises. (n=27)	No exercise, control group continued daily routine. (n=27)	6 weeks (18 sessions)	Clinical Pilates exercises were an effective and safe method for patients with LDH, reducing pain and functional disability, improving flexibility, static and dynamic endurance, and partially enhancing quality of life.
Chang et al., 2022[9]	RCT	40 Age 20-79 years	QR code-linked video demonstrating home-based back muscle exercises; 3+ times/week recommended (n=20)	Verbal instructions only; no specific source or demonstration provided (n=20)	2 months	Patients in the QR code group, who performed home-based lower back exercises, showed significantly lower disability scores at 1-month and 2-month follow-ups compared with the control group. QR codes were effective in encouraging adherence to home-based exercises in patients with LDH or lumbar spinal stenosis.
Danazumi et al., 2021[10]	RCT	60 Age 36-59 years	Group 1: Spinal mobilization with leg movement(SMWLM) Neural tissue mobilization. (n=20)Group 2: Progressive inhibition of neuromuscular structures(PINS).Neural tissue mobilization.(n=20)	Group 3: Combined SMWLM + PINSNeural tissue mobilization. (n=20)	3 months (2x/week)	Combined spinal mobilization with leg movement and progressive inhibition of neuromuscular structures therapy, along with a structured home exercise programme, was more effective than either technique alone in improving pain, function, and overall clinical outcomes in individuals with lumbar radiculopathy secondary to LDH.

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Author, Year	Design	Sample,Age	Intervention	Comparator	Duration	Outcomes
Hao, 2021[22]	RCT	100 20-80 years	Traction combined with paraffinotherapy + standard medication.(n=50)	Traction alone + standard medicationn=50)	14 days (every other day)	Traction combined with paraffinotherapy demonstrated significant therapeutic efficacy in patients with LDH, alleviating lumbocrural pain and improving lumbar function. This treatment also enhanced quality of life, supporting its use as an effective intervention for LDH.
Hossain et al., 2021[16]	Assessor-blinded RCT (36 months)	68 patients Age 28-47 years	McKenzie repeated movements + manual therapy; 12 sessions over 4 weeks + standard care (hot pack, analgesics, stabilization exercises)(n=34)	Stretching + Maitland mobilization + standard care (hot pack, analgesics, stabilization exercises)n=34)	4 weeks (12 sessions), 6-month follow-up	The McKenzie manipulative therapy approach reported effective for pain, disability and participating in activities for single or multiple level LDH patients from day 1 to week 4 and the treatment effect extends after 6 months.
Plaza-Manzano et al., 2020[17]	RCT	32 patients Age (years): 18-60	Motor control exercises + neurodynamic mobilization (nerve slider targetting sciatic nerve).(n=16)	Motor control exercises alone.(n=16)	8 sessions over 4 weeks	The addition of neurodynamic mobilization to a motor control exercise programme reduced neuropathic symptoms and mechanical sensitivity in individuals with lumbar radiculopathy. However, it did not produce greater improvements in pain, disability, or pressure pain threshold compared with motor control exercises alone, and the between-group differences were not clinically significant.
Koçak et al., 2018[26]	RCT	48 patients Age (years): 18-65	Non-surgical spinal decompression (NSSD) using DRX9000 device + standard care.(n=24)	Conventional motorized traction (CMT) + standard care (n=24)	6 weeks (20 sessions)	Both CMT and NSSD were effective in reducing pain, improving functional status, and decreasing depressive symptoms in patients with chronic LBP associated with LDH. However, NSD showed no superiority over CMT in terms of pain, function, depression, or quality of life.
Aras et al., 2018[21]	RCT	44 patients Age (years): 22-80	Physiotherapy combination technique: PNF, neural mobilization, core stability, neuromuscular therapy(n=22)	Standard physiotherapyn =22)	4 weeks (12 sessions)	Both groups showed significant improvements in pain and function; however, the combination therapy group demonstrated greater overall benefits. Overall, the combined physiotherapy approach was more effective than standard physiotherapy in reducing pain and improving functional outcomes in patients with LDH.

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Abbreviations: RCT: Randomized controlled trial; ROM: Range of motion; MT: Manual therapy; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; PINS: Progressive inhibition of neuromuscular structures; SMWLM: Spinal mobilization with leg movement; AP: Anteroposterior; QOL: Quality of life; LDH: Lumbar disc herniation; LBP: Low back pain; QR: Quick Response; NSSD: Non-surgical spinal decompression; CMT: Conventional motorized traction; PNF: Proprioceptive neuromuscular facilitation; MRI: Magnetic resonance imaging; kg: Kilogram; min: Minutes; reps: Repetitions.

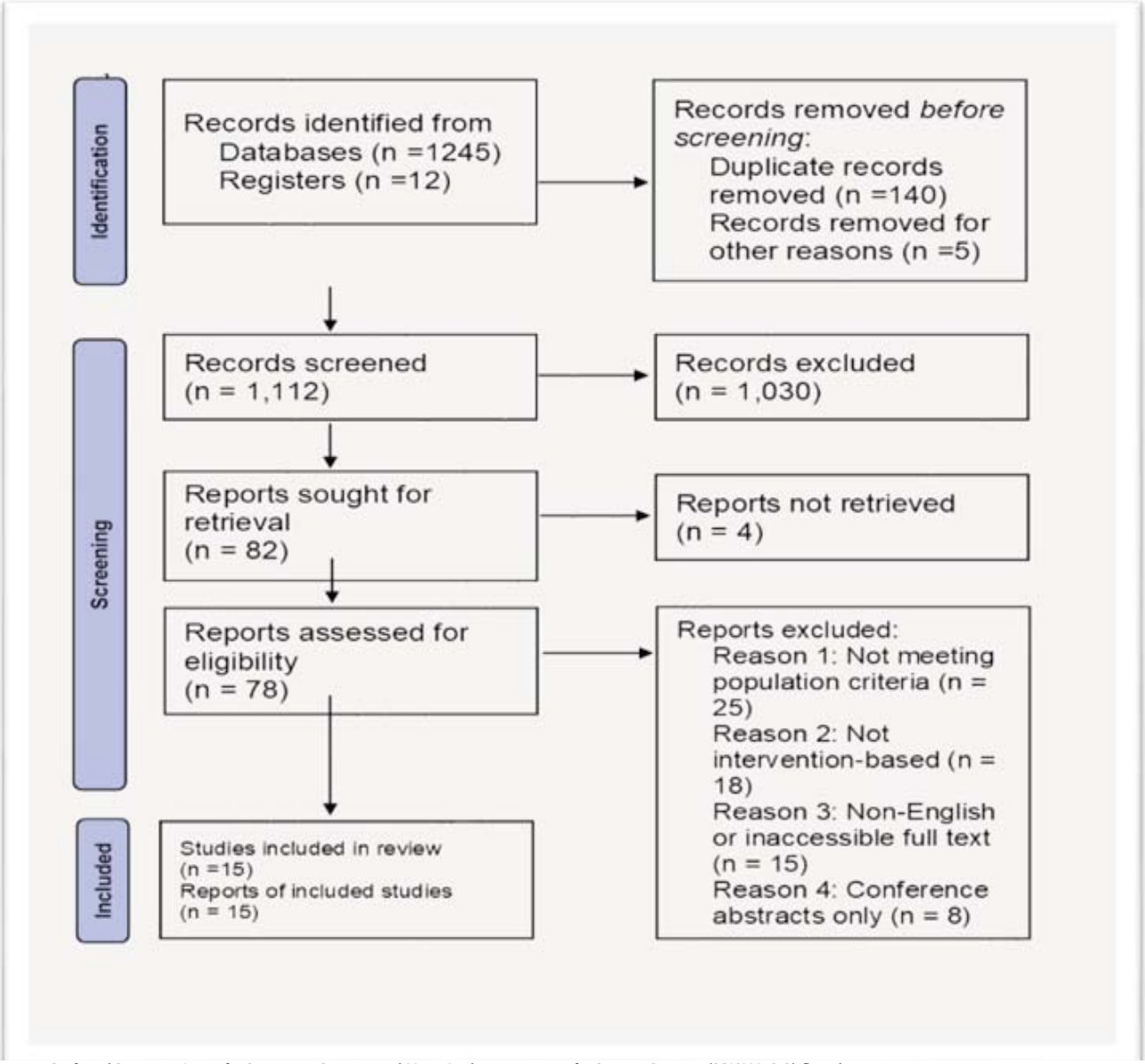
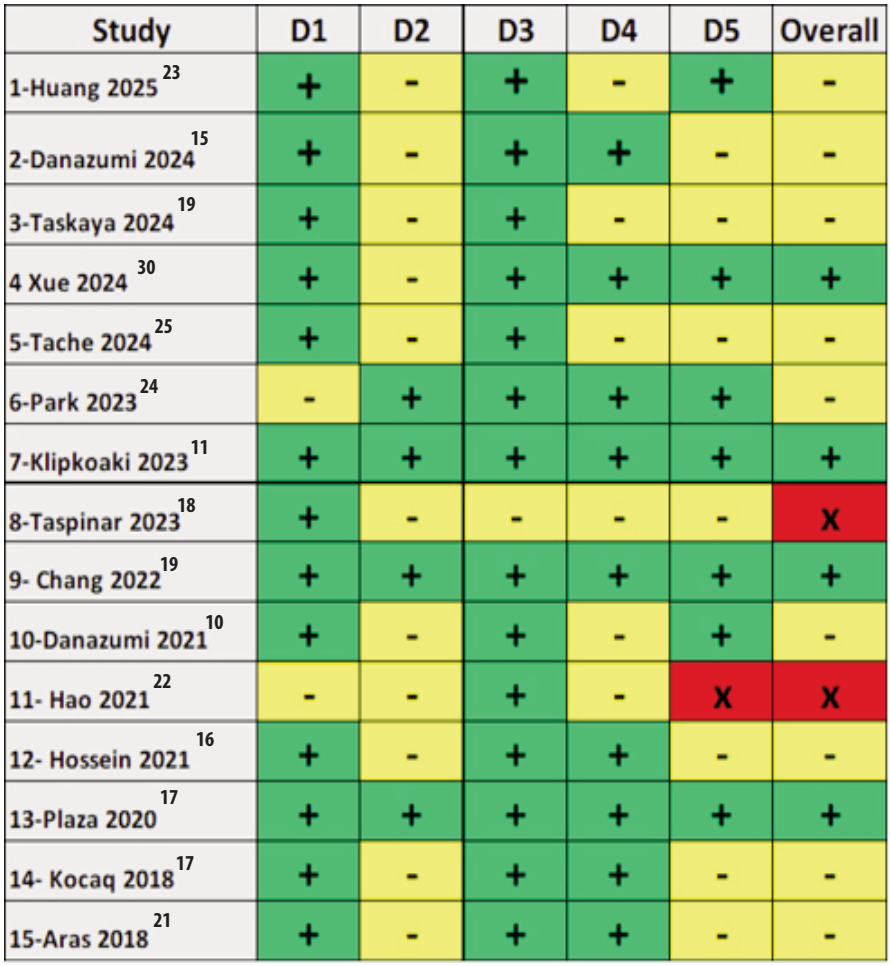


Figure-1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) flow diagram.

outcomes compared to exercise therapy alone.[15] Neurodynamic mobilisation with motor control exercises improved neuropathic symptoms and mechanosensitivity, but had similar effects on pain and disability compared to motor control alone.[17] Clinical pilates and physiotherapy combination techniques effectively reduced pain and disability while improving flexibility, trunk endurance and QOL.[18] Manual therapy combined with stabilization exercises significantly improved pain, kinesiophobia, pain catastrophizing, anxiety, depression, and QOL compared to exercise alone. These findings suggest beneficial psychological and functional effects of manual therapy in LDH rehabilitation.[19] Ma's bamboo-based medicinal



Study	D1	D2	D3	D4	D5	Overall
1-Huang 2025[23]	+	-	+	-	+	-
2-Danazumi 2024[15]	+	-	+	+	-	-
3-Taskaya 2024[19]	+	-	+	-	-	-
4 Xue 2024[30]	+	-	+	+	+	+
5-Tache 2024[25]	+	-	+	-	-	-
6-Park 2023[24]	-	+	+	+	+	-
7-Klipkoaki 2023[11]	+	+	+	+	+	+
8-Taspinar 2023[18]	+	-	-	-	-	X
9- Chang 2022[19]	+	+	+	+	+	+
10-Danazumi 2021[10]	+	-	+	-	+	-
11- Hao 2021[22]	-	-	+	-	X	X
12- Hossein 2021[16]	+	-	+	+	-	-
13-Plaza 2020[17]	+	+	+	+	+	+
14- Kocaq 2018[17]	+	-	+	+	-	-
15-Aras 2018[21]	+	-	+	+	-	-

Figure-2: Traffic-light plot showing risk of bias of the studies analysed (n = 15). The studies are listed by first author and year.

+: Low risk of bias, -: Unclear risk of bias, X: High risk of bias, D1: Randomisation process, D2: Deviations from intended interventions, D3: Missing outcome data, D4: Measurement of outcome, D5: Selection of reported result.

moxibustion was non-inferior to acupuncture in pain relief, and enhanced lumbar function.[20] Physiotherapy combination techniques integrating proprioceptive neuromuscular facilitation (PNF), neural mobilisation, core stability and neuromuscular therapy reduced pain and disability more effectively than standard physiotherapy.[21]

Traction with paraffinotherapy improved pain, lumbar function, range of motion (ROM) and QOL compared to traction alone.[22]

There were 5(33.3%) studies investigating technology-based approaches that included the use of portable lumbar exoskeleton, digital app-based physiotherapy, Quick Response (QR) code-linked exercise programmes, non-surgical spinal decompression and high-intensity laser therapy (Table).[9,23–26] QR code-guided exercise programmes increased adherence to home exercises and improved disability scores.[9] Portable lumbar exoskeleton therapy showed comparable improvements in pain, disability and ROM with traditional traction and resistance exercises.[23] Digital app-based physiotherapy improved pain, disability, mobility, functional performance and QOL, with higher patient satisfaction and cost-effectiveness.[24] High-intensity laser therapy combined with standard rehabilitation enhanced muscle strength and walking ability, and reduced fall risk compared to rehabilitation alone.[25] Non-surgical spinal decompression and conventional motorised traction both significantly improved pain, disability and depression in LDH patients. No significant differences were observed between the two interventions, and minimal changes occurred in QOL ($p>0.05$).[26]

Discussion

The current scoping review found that conventional physiotherapy interventions for LDH consistently yield significant clinical improvements. Core stabilisation and extension exercises, manual mobilisations, traction and other targeted regimens were repeatedly reported to reduce pain and disability, consistent with prior evidence .[27]

Specific exercise-based approaches may further enhance outcomes. An eight-week dynamic neuromuscular stabilisation programme has been shown to significantly reduce pain, improve lumbar mobility, decrease functional disability and enhance trunk muscle endurance, suggesting that neuromuscular control and spinal stabilisation mechanisms play a critical role in symptom improvement.[28]

Programmes combining stabilisation exercises with manual therapy or neural mobilisation tended to outperform single-modality treatments. For example, adding spinal mobilisation to core exercises yielded larger gains in function, and reductions in pain-related fear (kinesiophobia) than exercise alone.[29] In contrast, evidence indicates that lumbar stabilisation exercises may

not influence systemic inflammatory or neuroendocrine biomarkers, such as cytokines and endocannabinoids, despite clear clinical improvements.[30] This discrepancy suggests that the therapeutic effects of physiotherapy may be mediated primarily through biomechanical and neuromuscular adaptations rather than systemic inflammatory modulation.

Technology-assisted strategies, including QR code-guided home exercise programmes and combined neurodynamic mobilisation with motor control exercises, have demonstrated higher methodological quality and stronger levels of evidence compared to several conventional trials.[31] The current findings indicate that both conventional physiotherapy and technology-assisted interventions are effective in improving pain, disability and functional outcomes in LDH individuals. These results are supported by evidence showing that combined non-operative treatment programmes are effective and well tolerated, reinforcing the role of multimodal conservative management in symptom control and functional recovery.[32] Such findings highlight the clinical value of integrating multiple non-invasive strategies to address the multifactorial nature of LDH.

Adjunctive physical modalities appear to further enhance treatment outcomes. Evidence comparing high-intensity and low-intensity laser therapy suggests that high-intensity laser therapy, when combined with exercise, provides superior pain relief at rest, while both laser doses yield comparable improvements in pain during activity and disability.[33] This supports the use of dose-optimised, technology-assisted modalities as effective complements to conventional exercise-based rehabilitation.

Technology-enabled patient education also aligns with the present review's findings regarding feasibility and adherence. Mobile application-based educational interventions have been shown to be practical and acceptable for improving postoperative care following lumbar disc herniation surgery, particularly in resource-limited settings.[34] These approaches may enhance self-management, continuity of care, and patient engagement, which are increasingly recognised as critical components of successful rehabilitation.

In addition, complementary therapies may offer symptom-specific benefits. The use of Baimai ointment demonstrated significantly greater pain relief compared to placebo, suggesting that adjunctive traditional or topical therapies may play a role in pain modulation when integrated into comprehensive non-surgical management plans.[35] Collectively, these findings support a patient-centred, multimodal approach that combines conventional physiotherapy with technological and adjunctive interventions to optimise clinical outcomes in LDH. Evidence comparing high-intensity and low-intensity laser therapy suggests that high-intensity laser therapy, when combined with exercise, provides superior pain relief at rest, while both laser doses yield comparable improvements in pain during activity and disability. This supports the use of dose-optimised, technology-assisted modalities as effective complements to conventional exercise-based rehabilitation.[36]

The findings of the present scoping review align closely with previous review evidence emphasising a shift in LDH management towards conservative, minimally invasive and multidisciplinary care models. Earlier scoping reviews have highlighted that integrating traditional physiotherapeutic strategies with emerging technologies supports a more personalised and patient-centred approach to LDH management. Consistent with this evolving paradigm, the current review demonstrates that conventional physiotherapy interventions reliably improve pain, disability and functional outcomes, while technology-assisted approaches achieve comparable clinical effectiveness with additional benefits in treatment adherence, patient satisfaction and feasibility. Furthermore, prior reviews underscore the importance of conservative therapy as a primary treatment option for herniated discs, particularly when multiple therapeutic modalities are combined. This reinforces the present findings that multimodal physiotherapy whether delivered through conventional methods, technological platforms, or their integration can optimise rehabilitation outcomes and reduce reliance on invasive interventions.[37,38]

These approaches appear particularly effective in improving adherence, standardising exercise delivery, and supporting self-management. Technology-assisted rehabilitation is rapidly augmenting LDH care. A recent review found that a wearable lumbar exoskeleton can safely deliver traditional decompression and exercise benefits through a portable, home-friendly device.[39] Other innovations include VR and biofeedback devices. Immersive VR games have been used to distract patients from pain, and reinforce proper movement patterns. Early trials suggest VR is well-tolerated, but they are limited by small sample sizes and short follow-up.[40] Wearable feedback devices, like inertial sensors and electromyography monitors, allow patients to self-correct posture or opt for muscle activation in real time.[41]

These rehabilitation advances directly support SDG-3 by expanding access to care. The World Health Organisation (WHO) explicitly notes that strengthening rehabilitation

services is essential for achieving SDG-3 targets, particularly reducing disability from no communicable diseases.[42] Physiotherapy delivered remotely ensures equitable access to care for populations with limited local healthcare services.

The current review has limitations as the RCTs varied in exercise protocols, manual techniques and adjunct modalities, limiting direct comparisons and synthesis. Most trials measured outcomes only immediately post-treatment (a few weeks to a few months). Long-term effects, like recurrence and return-to-work data, remained largely unknown. Only a few studies assessed cost-effectiveness or broad QOL impacts, leaving a critical gap for the policymakers.

Conclusion

Non-surgical management of LDH encompasses diverse physiotherapeutic and adjunct interventions. Current evidence supports exercise-based rehabilitation, manual therapy and selected adjunct modalities in improving pain and functional outcomes. Technology-assisted approaches demonstrate comparable effectiveness to conventional care. Further high-quality trials with longer follow-up are needed to clarify long-term benefits and standardise treatment parameters.

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References

1. Wang L, Ye H, Li Z, Lu C, Ye J, Liao M, et al. Epidemiological trends of low back pain at the global, regional, and national levels. Eur Spine J. 2022;31:953–62. doi:10.1007/s00586-022-07133-x.
2. Pojskic M, Bisson E, Oertel J, Takami T, Zygourakis C, Costa F. Lumbar disc herniation: epidemiology, clinical and radiologic diagnosis WFNS Spine Committee recommendations. World Neurosurg X. 2024;24:100279. doi:10.1016/j.wnsx.2024.100279.
3. Geurts JW, Willems PC, Kallewaard JW, Van Kleef M, Dirksen C. The impact of chronic discogenic low back pain: costs and patients' burden. Pain Res Manag. 2018;2018:4696180. doi:10.1155/2018/4696180.
4. Penchev P, Ilyov IG, Todorov T, Petrov PP, Traykov P. Comprehensive analysis of treatment approaches for lumbar disc herniation: a systematic review. Cureus. 2024;16. doi:10.7759/cureus.67899.
5. Lee JS, Lee SB, Kang KY, Oh SH, Chae DS. Review of recent treatment strategies for lumbar disc herniation focusing on nonsurgical and regenerative therapies. J Clin Med. 2025;14:1196. doi:10.3390/jcm14041196.
6. Li R, Li Y, Kong Y, Li H, Hu D, Fu C, et al. Virtual reality-based training in chronic low back pain: systematic review and meta-analysis of randomized controlled trials. J Med Internet Res. 2024;26. doi:10.2196/45406.
7. Lakioti E, Pagonis N, Flegkas D, Itziou A, Moustakas K, Karayannis V. Social factors and policies promoting good health and well-being as a sustainable development goal: current achievements and future pathways. Sustainability. 2025;17:5063. doi:10.3390/su17115063.
8. Amir-Behghadami M, Janati A. Population, intervention, comparison, outcomes and study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. Emerg Med J. 2020;37:387. doi:10.1136/emermed-2020-209567.
9. Chang MC, Park D, Choo YJ. Use of QR codes for promoting a home-based therapeutic exercise in patients with lumbar disc herniation and lumbar spinal stenosis: a prospective randomized study. J Pain Res. 2022;15:4065–73. doi:10.2147/JPR.S391735.
10. Danazumi MS, Bello B, Yakasai AM, Kaka B. Two manual therapy techniques for management of lumbar radiculopathy: a randomized clinical trial. J Osteopath Med. 2021;121:391–400. doi:10.1515/jom-2020-0261.
11. Kilpikoski S, Häkkinen AH, Repo JP, Kyrölä K, Multanen J, Kankaanpää M, et al. The McKenzie method versus guideline-based advice in the treatment of sciatica: 24-month outcomes of a randomised clinical trial. Clin Rehabil. 2024;38:72–84. doi:10.1177/02692155231196393.
12. Veroniki AA, Hutton B, Stevens A, McKenzie JE, Page MJ, Moher D, et al. Update to the PRISMA guidelines for network meta-analyses and scoping reviews and development of guidelines for rapid reviews: a scoping review protocol. JBI Evid Synth. 2025;23:517–26. doi:10.11124/JBIES-24-00308.
13. Ahmad D. Current physiotherapeutic interventions and technological advancements in the management of lumbar disc herniation: a scoping review aligned with SDG 3 [Internet]. 2025 [cited 2026 May 21]. Available from: https://osf.io/5ygrm/overview
14. Flemyng E, Moore TH, Boutron I, Higgins JP, Hróbjartsson A, Nejstgaard CH, et al. Using Risk of Bias 2 to assess results from randomised controlled trials: guidance from Cochrane. BMJ Evid Based Med. 2023;28:260–6. doi:10.1136/bmjebm-2022-112102.
15. Danazumi MS, Adamu IA, Usman MH, Yakasai AM. Manual therapy plus sexual advice compared with manual therapy or exercise therapy alone for lumbar radiculopathy: a randomized controlled trial. J Osteopath Med. 2025;125:25–34. doi:10.1515/jom-2023-0075.
16. Hossain MA, Jahid IK, Hossain MdF, Uddin Z, Kabir MdF, Hossain KMA, et al. Efficacy of McKenzie manipulative therapy on pain, functional activity and disability for lumbar disc herniation [Internet]. 2020 [cited 2025 Jun 24]. Available from: http://medrxiv.org/lookup/doi/10.1101/2020.07.13.20152843. doi:10.1101/2020.07.13.20152843.
17. Plaza-Manzano G, Cancela-Cilleruelo I, Fernández-de-Las-Peñas C, Cleland JA, Arias-Buría JL, Thoomes-de-Graaf M, et al. Effects of adding a neurodynamic mobilization to motor control training in patients with lumbar radiculopathy due to disc herniation: a randomized clinical trial. Am J Phys Med Rehabil. 2020;99:124–32. doi:10.1097/PHM.0000000000001295.
18. Taşpınar G, Angın E, Oksüz S. The effects of Pilates on pain, functionality, quality of life, flexibility and endurance in lumbar disc herniation. J Comp Eff Res. 2023;12. doi:10.2217/cer-2022-0144.
19. Taşkaya B, Taşkent İ, Çakıllı M, Yılmaz Ö. The effect of manual therapy on psychological factors and quality of life in lumbar disc herniation patients: a single-blinded randomized clinical trial. Int J Environ Res Public Health. 2024;21:1234. doi:10.3390/ijerph21091234.

20. Xue K, Wang X, Xiao C, Zhang N, Liu M, Fu J, et al. Clinical efficacy and safety of a modified moxibustion therapy for low back pain in lumbar disc herniation: a two-center, randomized, controlled, non-inferiority trial. J Pain Res. 2024;17:1853–65. doi:10.2147/JPR.S457724.21.
21. Aras D, Ahmad H. The efficacy of physiotherapy combination technique on pain and functional independence of people with lumbar disc herniation: physiotherapy combination technique, a conservative treatment for lumbar disc herniation. Indian J Public Health Res Dev 2018;9:1524–9. doi:10.5958/0976-5506.2018.00949.X.
22. Hao F. Analysis of the effect of traction combined with paraffinotherapy on lumbar function in patients with lumbar disc herniation. Am J Transl Res 2021;13:6759–65.
23. Huang X, Huang L, Shi L, Xu L, Cao C, Wu H, et al. Evaluation of the efficacy of a novel lumbar exoskeleton with multiple interventions for patients with lumbar disc herniation: a multicenter randomized controlled trial of non-inferiority. Front Bioeng Biotechnol 2025;12:1520610. doi:10.3389/fbioe.2024.1520610.
24. Park C, Yi C, Choi WJ, Lim HS, Yoon HU, You SH. Long-term effects of deep-learning digital therapeutics on pain, movement control, and preliminary cost-effectiveness in low back pain: a randomized controlled trial. Digit Health 2023;9:20552076231217817. doi:10.1177/20552076231217817.
25. Tache-Codreanu DL, Trăistaru MR. The effectiveness of high intensity laser in improving motor deficits in patients with lumbar disc herniation. Life (Basel) 2024;14:1302. doi:10.3390/life14101302.
26. Koçak FA, Tunç H, Tomruk Sütbeyaz S, Akkuş S, Köseoğlu BF, Yılmaz E. Comparison of the short-term effects of conventional motorized traction with non-surgical spinal decompression performed with a DRX9000 device on pain, functionality, depression, and quality of life in patients with low back pain associated with lumbar disc herniation: a single-blind randomized controlled trial. Turk J Phys Med Rehabil 2018;64:17–27. doi:10.5606/tftrd.2017.154.
27. Thavarajasingam SG, Ramsay DSC, Namireddy SR, Kamath AG, Kanakala S, Zaidi H, et al. Exercise, manipulation and traction physiotherapy in the conservative management of lumbar disc herniation: a systematic review and meta-analysis. Brain Spine 2025;5:105632. doi:10.1016/j.bas.2025.105632.
28. Ameri B, Fatahi A, Abadi RN, Molavian R. Dynamic neuromuscular stabilization exercise and chronic lumbar disc herniation: effects on pain, mobility, and trunk endurance—a randomized controlled trial. Health Sci Rep 2025;8:e71611. doi:10.1002/hsr2.71611.
29. Singh V, Malik M, Kaur J, Kulandaivelan S, Punia S. A systematic review and meta-analysis on the efficacy of physiotherapy intervention in management of lumbar prolapsed intervertebral disc. Int J Health Sci (Qassim) 2021;15:49–57.
30. Morkoç B, Aktan O, Sönmez G, Bodur E, Karakaya J, Kaymak B, et al. Effects of lumbar stabilization exercises on serum biomarker levels and clinical outcomes in lumbar disc herniation: a subgroup analysis of a randomized controlled trial. Turk J Med Sci 2025;55:572–84. doi:10.55730/1300-0144.6004.
31. Arslan S, Ülger Ö. The effect of exercise in the treatment of lumbar disc herniation: a systematic review. Acta Neurol Belg. 2025. doi:10.1007/s13760-025-02767-2.
32. Benzakour T, Igoumenou V, Mavrogenis AF, Benzakour A. Current concepts for lumbar disc herniation. Int Orthop. 2019;43:841–51. doi:10.1007/s00264-018-4247-6.
33. Shiwen L, Tianyu H, Valentinovich IA, Jiayuan X, Wenyu W, Quan Q. MRI changes and clinical results of low energy semiconductor percutaneous laser disc decompression (LS-PLDD) for lumbar disc herniation in adolescents. Lasers Med Sci. 2025;40:481. doi:10.1007/s10103-025-04730-2.
34. Silveira AMC, Comachio J, Mesa-Castrillon C, Roberts K, Beckenkamp P, Ho EK, et al. My Back Exercise app: an automated exercise intervention supported by educational notifications, a sleep programme and diet advice to improve function in people with chronic non-specific low back pain – protocol for a superiority, adaptive multi-arm multi-stage randomised controlled trial. BMJ Open. 2025;15:e098324. doi:10.1136/bmjopen-2024-098324.
35. Sun C, Sun K, Wang S, Wang Y, Yuan P, Li Z, et al. Effect of Baimai ointment on lumbar disc herniation: a multicentre, prospective, randomised, double-blind, placebo-controlled trial. Phytomedicine. 2024;122:155138. doi:10.1016/j.phymed.2023.155138.
36. Kuzu Ş, Jawad SR, Canli M, Özüdoğru A. Investigation of efficacy of high and low intensity laser therapy in patients with lumbar disc herniation: a randomized controlled trial. J Med Biol Eng. 2025;45:738–44. doi:10.1007/s40846-025-00989-6.
37. Sturm C, Schiller J, Egen C, Ranker A, Lemhöfer C, Bökel A. Conservative therapy in lumbar disc herniation. Orthopädie. 2024;53:918–27. doi:10.1007/s00132-024-04579-3.
38. Tong Y, Yu L, Luo K, Yan X, Chen M, Wang L. Recent advances and evolving strategies in the treatment of lumbar disc herniation. Front Neurol. 2025;16:1706784. doi:10.3389/fneur.2025.1706784.
39. Qu Y, Wang X, Tang X, Liu X, Hao Y, Zhang X, et al. A review of wearable back-support exoskeletons for preventing work-related musculoskeletal disorders. Biomimetics. 2025;10:337. doi:10.3390/biomimetics10050337.
40. Buztepe S, Çapik C. The effect of exercises done with virtual reality glasses on pain, daily life activities, and quality of life of individuals with lumbar disc hernia: a randomized controlled trial. BMC Musculoskelet Disord. 2025;26:886. doi:10.1186/s12891-025-09130-9.
41. Lüddecke R, Felnhofer A. Virtual reality biofeedback in health: a scoping review. Appl Psychophysiol Biofeedback. 2022;47:1–15. doi:10.1007/s10484-021-09529-9.
42. Monaco S. Identity, territories, and sustainability: challenges and opportunities for achieving the UN sustainable development goals. Emerald Publishing Limited. 2024. doi:10.1108/9781837975495.

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