Invest Clin 67(2): 178 - 188, 2026 https://doi.org/10.54817/IC.v67n2a02

The effect of vitamin D_3 combined with traction on the treatment of lumbar disc herniation.

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Keywords: Cholecalciferol; Intervertebral Disc Herniation; Traction; Inflammation; Pain; Rehabilitation.

Abstract. This study examined the clinical effectiveness of vitamin D_3 combined with traction therapy in patients with lumbar disc herniation. It included 112 patients who received conservative rehabilitation at our hospital from January 2021 to December 2023. Participants were randomly assigned to two groups: one received supine mechanical traction, and the other received the same traction plus oral vitamin D_3 for 4 weeks. The study compared clinical outcomes and quality of life between the groups. Results showed that both groups experienced improvements in pain and lumbar spine function. However, the combined treatment group showed significantly better outcomes than the traction-only group. Inflammation and pain markers decreased significantly, and 25(OH)D_3 levels increased notably in both groups, with greater improvements in the combined treatment group. Additionally, negative mood and quality of life improved more in the combined group. There was no significant difference in the measured indicators between the one-month follow-up and the one-month treatment. In conclusion, vitamin D_3 combined with traction therapy can effectively enhance short-term clinical outcomes and quality of life for patients with lumbar disc herniation.

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Evaluación de la eficacia clínica de la vitamina D_3 combinada con la tracción en pacientes con hernia de disco lumbar.

Invest Clin 2026; 67 (2): 178 – 188

Palabras clave: Vitamina D_3; Hernia de disco intervertebral; Tracción; Inflamación; Dolor; Rehabilitación.

Resumen. Este estudio se centró en evaluar la eficacia clínica de la terapia combinada con vitamina D_3 y tracción en pacientes con hernia de disco lumbar. Se incluyeron 112 pacientes que recibieron tratamiento de rehabilitación conservador en nuestro hospital entre enero de 2021 y diciembre de 2023. Los pacientes fueron asignados aleatoriamente a dos grupos: uno recibió únicamente tratamiento de tracción y el otro, tracción más tratamiento oral con vitamina D_3 durante 4 semanas. Se compararon la eficacia clínica y la calidad de vida entre ambos grupos. Los resultados mostraron que ambos tratamientos mejoraron el nivel de dolor y la función lumbar, aunque la combinación de vitamina D_3 con tracción produjo una mejora significativamente mayor. Los marcadores de inflamación y dolor disminuyeron notablemente, y los niveles de 25(OH)D_3 aumentaron en ambos grupos, con una mejoría mayor en el grupo combinado. Además, el estado de ánimo y la calidad de vida mejoraron de forma más significativa en el grupo de tratamiento combinado. No se observaron diferencias estadísticamente significativas entre los indicadores de prueba al mes de seguimiento y al de tratamiento. En conclusión, la combinación de vitamina D_3 y terapia de tracción puede mejorar eficazmente los resultados clínicos a corto plazo y la calidad de vida de los pacientes con hernia discal lumbar.

Received: 27-08-2025 *Accepted: 22-11-2025*

INTRODUCTION

Lumbar degenerative disc disease (LDDD) is a leading cause of musculoskeletal disorders, with lumbar disc herniation (LDH) being its primary manifestation [1]. LDH occurs when disc material (nucleus pulposus or annulus fibrosus) displaces beyond the intervertebral disc space, causing symptoms such as nerve root pain, numbness, decreased sensation, and weakness [2,3]. In severe cases, it can result in paralysis or cardiovascular issues. It is more common in individuals aged 30 to 50, with men being twice as likely as women [4]. Over 50% of people with lumbar disc disease report lower back pain, which significantly impairs quality of life [5]. Conservative treatment remains the first choice for most LDH patients [6]. Pain relief is mainly achieved through medication, physiotherapy, exercise, traction, epidural steroid injections, and acupuncture [7]. Surgery is typically reserved for severe LDH cases that do not respond to conservative approaches. While minimally invasive procedures like microdiscectomy offer good long-term results for select patients, traditional open surgery carries risks such as recurrent herniation and post-operative complications [8].

Traction therapy is a conservative treatment commonly used in clinical practice that can increase the intervertebral space and reduce intervertebral pressure through physical pulling, thereby improving lumbar disc-related symptoms such as acidity, numbness, swelling, and pain [9]. However, traction therapy slightly raises the risk of lumbar spine injury [10]. Previous meta-analyses, including Tadano et al. [11], confirm that mechanical traction in the supine position offers short-term pain relief in radiculopathy, although long-term effectiveness varies and depends on the patient.

Vitamin D is a widely used neurosteroid hormone with multiple skeletal and non-skeletal functions. Vitamin D receptors have been identified in bone marrow, and several reports have demonstrated a regulatory role for vitamin D in bone metabolism and osteoporosis [12,13]. Research on the relationship between vitamin D receptors and lumbar disc degeneration and herniation has become a hot topic [14-16]. Mechanistic studies have found that vitamin D has a protective effect against neurotoxicity and can reduce pain by modulating neurons [17], in addition to reducing inflammation and pain in patients by down-regulating the release of pain-producing inflammatory factors from glial cells[18,19]. However, there is less information about the clinical application of vitamin D in LDH.

This study focuses on the short-term clinical effects of supine mechanical traction therapy and oral vitamin D_3 supplementation in patients with LDH.

MATERIALS AND METHODS

Study subjects

One hundred and twelve outpatients with LDH receiving conservative treatment at the Rehabilitation Department of Xinhua Hospital, affiliated with the Shanghai Jiaotong University School of Medicine (Changxing Branch, Shanghai, China), between January 2021 and December 2023, were enrolled. Inclusion criteria: (1) LDH confirmed by magnetic resonance imaging (MRI); (2) radicular pain (VAS ≥4); (3) no treatment in the previous six months. Exclusion criteria: (1) severe spinal pathology; (2) cardiac or hepatic dysfunction; (3) malignancy or autoimmune disease; (4) recent vitamin D use; (5) inability to comply. The study was approved by the Ethics Committee of Xinhua Hospital (Approval No. 2021-001).

Treatment protocol

The control group (CG) received supine mechanical traction using a Lumbar Traction Device (Model: TR-200, China). Pelvis and thorax were fixed, and intermittent traction was applied at 50–80% of body weight (adjusted for tolerance). Sessions lasted 20 minutes per day, 5 days a week, for 4 weeks. Patients rested in a supine position for 30 minutes after traction. The observation group (OG) received the same traction protocol plus oral vitamin D_3 (800 IU/day; Cholecalciferol, 1000 IU capsules, Shanghai Pharma) for 4 weeks.

Observation indicators

1. **Lumbar function/pain:** JOA [20], ODI [20], VAS [20].
2. **Efficacy:** Classified as significant (JOA↑>75%, VAS↓>75%), effective (JOA↑35–75%, VAS↓25–75%), ineffective (JOA↑<35%, VAS↓<25%) [21].
3. **Inflammation/pain:** Serum IL-1β, TNF-α, IL-6, IL-8, 25(OH)D_3, SP, 5-HT, PGE_2 (ELISA kits, R&D Systems).
4. **Complications:** Assessed via clinical evaluation and MRI at follow-up.
5. **Negative emotions:** SAS [21], SDS [21].
6. **Quality of life:** LHFQ [22].

Abbreviations: LDH – Lumbar Disc Herniation, VAS – Visual Analogue Scale, JOA – Japanese Orthopaedic Association Score, ODI – Oswestry Disability Index, IL-1β – Interleukin-1 Beta, TNF-α – Tumor Necrosis Factor-Alpha, IL-6 – Interleukin-6, IL-8 – Interleukin-8, 25(OH)D_3 – 25-Hydroxyvitamin D_3, SP – Substance P, 5-HT – 5-Hydroxytryptamine (Serotonin), PGE_2 – Prostaglandin E_2, SAS – Self-Rating Anxiety Scale, DS – Self-Rating Depression Scale, LHFQ – Lumbar Health Functional Questionnaire.

Statistical analysis

Data were analyzed with IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean ± standard deviation (SD). The paired sample t-test was used for within-group (pre- and post-treatment) comparisons, while the independent sample t-test was employed for between-group comparisons. Categorical data were compared using the Chi-square (χ^2) test or Fisher's exact test when appropriate. Statistical significance was defined as $p<0.05$.

RESULTS

Improvement in lumbar spine function and pain level after treatment

As shown in Fig. 1, the JOA scores for both groups increased, while the ODI and VAS scores decreased after treatment, and the OG scores were significantly better than those of CG ($p<0.05$). The one-month follow-up results after treatment showed no statistically significant differences in lumbar spine function and pain levels compared to the post-treatment period ($p>0.05$).

Combination therapy improves clinical outcomes

As shown in Table 1, OG's treatment efficiency was significantly higher than CG's ($p<0.05$).

Combination therapy improves inflammatory factors and vitamin D levels

As shown in Fig. 2, the levels of IL-1β, TNF-α, IL-6, and IL-8 were lower in both groups after treatment, with a greater decrease in OG than in CG ($p<0.05$). The levels of 25(OH)D_3 in the patients increased following vitamin D_3 supplementation.

As shown in Fig. 3, SP, 5-HT, and PGE_2 decreased in both groups, and OG decreased more than CG ($p<0.05$).

Assessment of the incidence of complications in both groups

As shown in Table 2, the complication rate of OG had a decreasing trend compared with that of CG, but there was no statistically significant difference between the two ($p>0.05$).

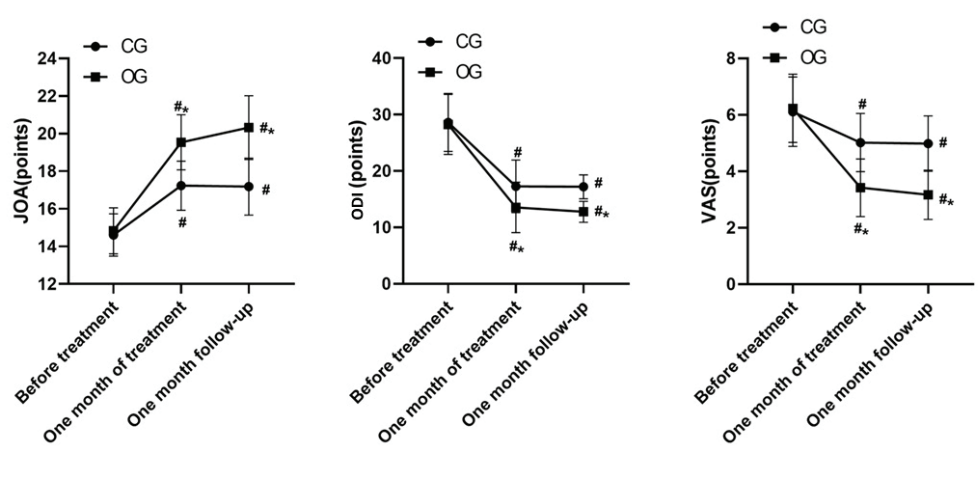

Fig. 1. Comparison of lumbar spine function and pain level. *$p<0.05$ compared with CG, #$p<0.05$ compared with before treatment. JOA: Japanese Orthopaedic Association Score; ODI: Oswestry Disability Index; VAS: Visual Analogue Scale; CG: Control Group; OG: Observational Group. Data are presented as mean ± SD. Independent sample t-test and paired sample t-test were used for between- and within-group comparisons, respectively.

Table 1. Comparison of treatment efficacy (%).

Groups	Obviously effective	Effective	Ineffective	Effective rate
CG (n =56)	30(53.57)	12(21.43)	14(25.00)	75.00
OG (n =56)	35(62.50)	15(26.79)	6(10.71)	89.29
χ2				3.896
p				0.048

CG: Control Group; OG: Observational Group. Data, expressed as n (%), were compared using the Chi-square (χ^2) test, $p<0.05$ indicates statistical significance.

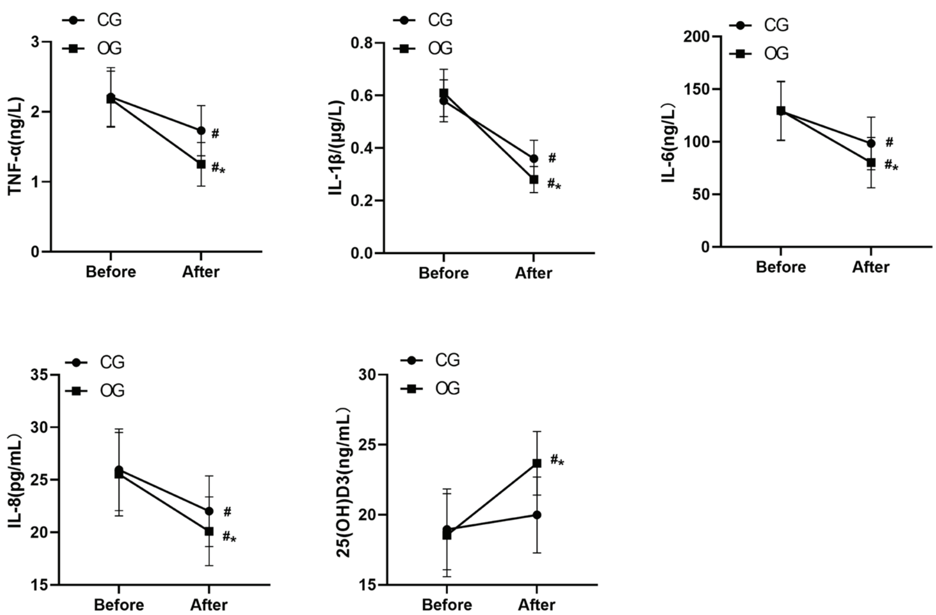

Fig. 2. Comparison of inflammatory factors and vitamin D levels. *$p<0.05$ compared with CG, #$p<0.05$ compared with before treatment. IL-1β: Interleukin-1 Beta; TNF-α: Tumor Necrosis Factor-Alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; $25(OH)D_3$ – 25-Hydroxyvitamin D_3; CG: Control Group; OG: Observational Group. Data are presented as mean ± SD. Independent and paired sample t-tests were used.

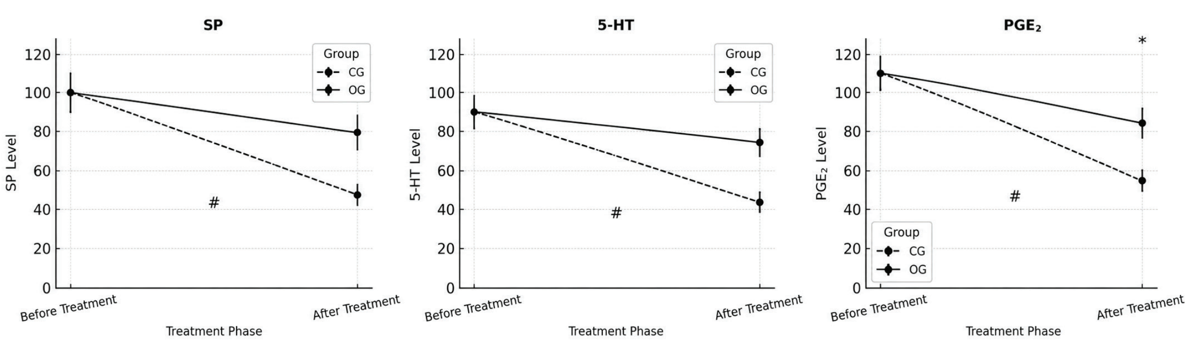

Fig. 3. Comparison of pain-related indicators. *$p<0.05$ compared with CG, #$p<0.05$ compared with before treatment. SP: Substance P; 5-HT: 5-Hydroxytryptamine; PGE_2: Prostaglandin E_2; CG: Control Group; OG: Observational Group. Data expressed as mean ± SD. Statistical comparisons were performed using independent sample t-tests and paired sample t-tests.

Table 2. Comparison of complications.

Groups	Nerve root compression	Intervertebral disc degeneration	Narrowing of the spinal canal	Total incidence rate
CG (n =56)	3 (5.36)	3(5.36)	2(3.57)	8(14.29)
OG (n =56)	1(1.79)	1(1.79)	0(0.00)	2(3.57)
$\chi2$				-
p				0.094

CG: Control Group; OG: Observational Group. Data are expressed as n (%), compared using the Chi-square (χ^2) test, $p<0.05$ is considered statistically significant.

Combination therapy reduces negative emotions

As displayed in Fig. 4, SDS and SAS scores decreased in both groups after treatment, with OG scores being lower than CG ($p<0.05$). The follow-up results after one month showed no significant difference compared to those immediately after treatment ($p>0.05$).

Combination therapy improves Quality of Life (QOL)

As shown in Fig. 5, LHFQ scores improved after treatment in both groups, with OG scores lower than those in the CG ($p<0.05$).

DISCUSSION

This study assessed the short-term effectiveness of combining oral vitamin D_3 with supine mechanical traction for LDH. The primary finding was that combination therapy significantly enhanced pain relief, functional ability, inflammation reduction, and quality of life compared to traction alone. Specifically, this integrated approach led to a notable decrease in nerve root pain and better functional outcomes versus traditional conservative treatments. Nerve root pain is a common persistent issue that hampers daily activities for people with LDH. Local inflammatory responses are caused by malfunctioning muscles and soft tissues, which lead to herniation that compresses the nerve root. Disc inflammation contributes to disc degeneration or herniation through ongoing inflammation and production of inflammatory factors. Additionally, the nucleus pulposus releases inflammatory agents by activating the autoimmune system, worsening pain.

Traction therapy reduces soreness and pain by increasing the patient's lumbar intervertebral space and relieving the pressure caused by herniated nucleus pulposus. However, its effectiveness on lumbar intervertebral discs when used alone is limited, and prolonged traction can lead to drawbacks like instability of lumbar spinal muscles and ligaments. Vitamin D is a neurosteroid hormone that modulates the immune system, protects the central nervous system, and helps resist cell damage. Studies have shown a link between vitamin D and lumbar disc herniation. Yang et al. [23] found that levels of vitamin D receptor gene expression could serve as a marker for lumbar disc degeneration. Sedighi et al. [24] discovered that subcutaneous vitamin D_3 injections can decrease neural tension and improve sensory deficits related to lumbar discs. This study investigated the combined effects of traction therapy and vitamin D_3; unlike previous research, the vitamin therapy was administered orally, which is a new approach. Feedback on treatment effectiveness was assessed by observing changes in pain mediators and inflammatory factors.

Our results demonstrate that lumbar spine function and overall pain levels improved in both groups, with relief from com-

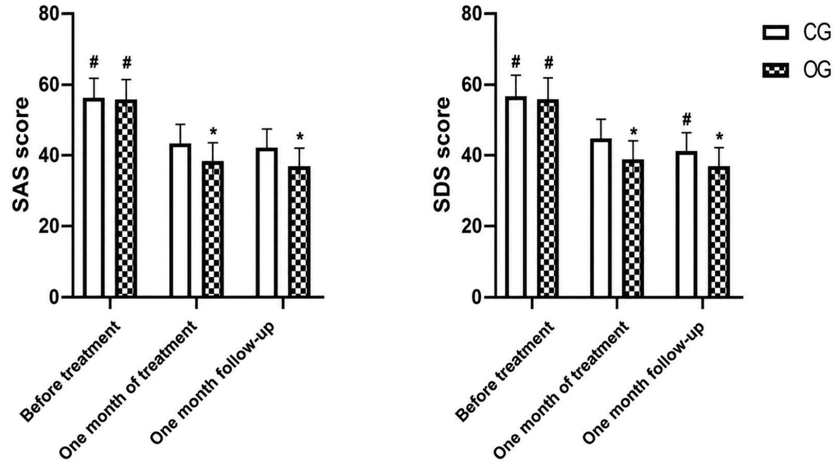

Fig. 4. Comparison of negative emotions. *p<0.05 compared with CG, #p<0.05 compared with one month of treatment. CG: Control Group; OG: Observational Group; SAS: Self-Rating Anxiety Scale; SDS: Self-Rating Depression Scale. Data are presented as mean ± SD. Statistical analysis performed using independent and paired sample t-tests.

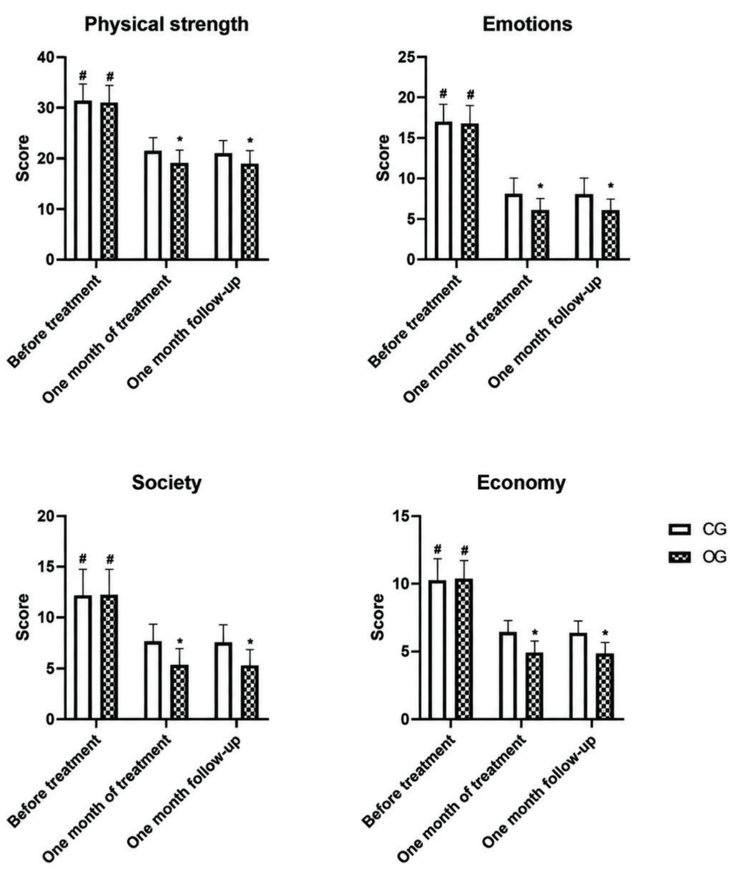

Fig. 5. Comparison of QOL. *p<0.05 compared with CG, #p<0.05 compared with one month of treatment. LHFQ: Lumbar Health Functional Questionnaire; CG: Control Group; OG: Observational Group. Data are presented as mean ± SD. Independent sample t-tests and paired sample t-tests were used for between- and within-group comparisons, respectively.

bination therapy exceeding that of monotherapy. The effectiveness of the treatments was assessed using the JOA and VAS scores, which showed superior results in the combined treatment group. To better understand the role of improved effectiveness, we tested patients for inflammatory and pain-related factors. Evidence suggests that vitamin D receptors, cytokines, apoptotic factors, and pain mediators contribute to the development of intervertebral disc herniation [25-27]. IL and TNF are the primary inflammatory mediators involved in lumbar disc disease. IL-1β is primarily secreted by mononuclear macrophages within the intervertebral disc, and elevated levels promote disc degeneration and pain. In one study, IL-1β was injected into the intervertebral space of a rat model, which caused inflammation and disc damage [28]. IL-8 and IL-6 can stimulate the release of inflammatory mediators, promote the recruitment of inflammatory cells, and accelerate the progression of intervertebral disc disease [29,30]. TNF-α is a potent inflammatory mediator that increases the release of other pro-inflammatory substances, induces apoptosis of chondrocytes, and affects osteoblast growth—key factors in lumbar disc pathology [31].

Furthermore, because pain mediators are key contributors to patient pain, we chose representative mediators—SP, 5-HT, and PGE_2—as our study subjects. Serum levels of SP, 5-HT, and PGE_2 were higher in patients with lumbar disc herniation than in healthy controls. SP is an injurious stimulatory neuropeptide found in nerve fibers with pain signaling capacity and has been linked to lumbar disc herniation pain [32]. 5-HT is a common pain mediator that transmits and modulates pain signals [33]. PGE_2 can activate sensory nerve receptors by lowering the pain threshold and increasing pain perception [34]. Our study showed that levels of inflammatory factors and pain mediators improved after treatment in both groups, with the combined treatment group experiencing greater relief.

Evidence suggests that vitamin D deficiency is prevalent among patients with lumbar degenerative spine conditions. Our findings showed that 25(OH)D_3 levels in patients were at deficient levels prior to treatment, and after four weeks of vitamin supplementation, there was a significant increase, approaching the normal range. Mechanistic studies have found that vitamin D interacts with vitamin D receptors in the paravertebral muscles, supporting injury recovery. In addition, vitamin D can inhibit neurotoxic factors through immunomodulation and modulate inflammatory cell populations, thereby contributing to inflammation and pain relief. IL-6, TNF-α, and prostaglandins released by glial cells are downregulated by vitamin D [35-37]. Therefore, we hypothesize that the improved efficacy of combination therapy is due to vitamin D's ability to inhibit the expression of inflammatory and pain mediators.

Statistics on patients' mood and quality of life, as measured by questionnaires, revealed that combination therapy provided significantly greater benefits than monotherapy. One-month follow-up results suggested that the efficacy of combination therapy was maintained beyond one month.

However, there are still some limitations to this study. Firstly, the sample size was small, which may introduce bias into the findings. Secondly, the vitamin D_3 supplementation dose was not graded, and the optimal oral dose was not identified. These shortcomings represent directions for future research.

The present study demonstrates that combining vitamin D_3 supplementation with mechanical traction yields superior clinical benefits compared with traction alone in patients with lumbar disc herniation (LDH). Beyond alleviating pain and improving lumbar function, the combined regimen effectively modulates inflammatory and neurochemical pathways, reflected by reductions in IL-1β, TNF-α, IL-6, IL-8, SP, 5-HT, and PGE_2 levels. These biochemical improvements parallel the enhancement in patients' quality of life and emotional well-being. The elevation of serum 25(OH)D_3 following therapy underscores the systemic contribution of vitamin D_3 to neuromuscular recovery and anti-inflammatory balance.

At a broader level, these findings substantiate the biopsychosocial impact of adjunctive vitamin D_3 therapy in musculoskeletal rehabilitation. By addressing both the physiological and psychological dimensions of LDH, vitamin D_3 with traction represents a biologically integrative and patient-centric approach that may redefine conservative management strategies. Future multicentric studies with larger cohorts and graded-dosing protocols are warranted to establish long-term efficacy, optimal dosing, and mechanistic insights into this synergistic interaction.

Funding

None.

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Author's contributions

Both authors contributed to the development and writing of the paper.

Conflict of interest

The authors state that there are no conflicts of interest to disclose.

Assurance of the originality of data

The author(s) assure the readers and the publishers that all the data presented here is original.

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