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Lumbar Core Muscle Stability Training Combined with Kinesiology Taping Technique in Rehabilitation Treatment of Lumbar Disc Herniation

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Abstract

Objective: This study mainly explored the therapeutical efficacy of kinesiology taping alone or in combination with lumbar core muscle stability rehabilitation in the rehabilitation of lumbar disc herniation (LDH), with the hope to provide references for the clinical rehabilitation treatment of this disease. **Methods:** A total of 99 eligible LDH patients admitted to Yinzhou Second Hospital of Ningbo from January 2018 to January 2020 were enrolled and randomly divided into control group (n = 49) and observation group (n = 50) using a random number table. In control group, patients received kinesiology taping treatment, while in observation group, patient underwent the combined treatment of kinesiology taping and lumbar core muscle stability rehabilitation training. The clinical efficacy, lumbar function and pain levels before and after treatment, surface electromyography (sEMG) values of lumbar and thoracic extensor muscles, lumbar functional activity, and incidence of skin allergies were compared between the two groups. **Results:** After 4 weeks of treatment, the Visual Analog Scale (VAS) score and Oswestry Disability Index (ODI) score in the observation group were significantly lower than those in the control group ($p < 0.05$), while the Japanese Orthopaedic Association (JOA) score, mean power frequency (MPF) and integrated electromyography (iEMG) of back extensor muscles, and lumbar functional activity scores were significantly higher than those in the control group ($p < 0.05$). During treatment, there was no significant difference in complication rates between the two groups ($p > 0.05$). After 4 weeks of treatment, the recurrence rate in the observation group was significantly lower than that in the control group ($p < 0.05$). **Conclusion:** The combined therapy of lumbar core muscle stability training and kinesiology taping technique can more effectively relieve muscle fatigue, contribute to alleviate lumbar pain and enhance lumbar functional activity, therefore it is superior to kinesiology taping technique alone in treating LDH.

1 Introduction

Lumbar disc herniation (LDH) is a series of common pain symptoms mainly represented as pain, numbness, soreness and distention in low back and legs. The causative factors are mainly degenerative changes in the nucleus pulposus and annulus fibrosus of the lumbar intervertebral discs, together with external pressure on the lumbar region, which incurs the rupture of the annulus fibrosus and herniation of the nucleus pulposus, as well as irritation or compression of adjacent nerves [1-2]. Kinesiology taping is a routine rehabilitation treatment for for soft tissue pain disorders, by which the pressure on pain receptors can be reduced, pain threshold can be elevated, excessive muscle contraction can be suppressed, better contributing to muscle coordination recovery in patients [3]. For LDH patients, degenerative changes in the intervertebral discs lead to reduced spinal stability, resulting in biomechanical dysfunction and impaired balance of the lumbar core muscles, ultimately causing muscle damage [4]. This suggests the substantial risk of decreased stability of the lumbar core muscles in LDH. Therefore, strengthening these muscles and improving their stability are crucial for preventing LDH and enhancing lumbar function in affected patients. Given the little report regarding the combined therapy of kinesiology taping and lumbar core muscle stability training in the rehabilitation of LDH, this study investigated the effects of this combined therapy on clinical symptoms and lumbar function in LDH patients, with an attempt to provide a reference for clinical rehabilitation strategies. The detailed research results can be referred as below.

2 Materials and methods

2.1 General information

An open-label trial was conducted in this study since the blinding method was not available. A total of 99 LDH patients admitted to our hospital between January 2018 and January 2020 were enrolled. Participants were sequentially numbered from 1 to 99 (with corresponding sealed envelopes). Subsequently, 99 random digits were transcribed in sequence from an arbitrarily chosen digit in a certain row of a random number table, with each digit matching to the participant number. Odd numbers were allocated to the observation group, while even numbers were assigned to the control group. Group assignments (along with corresponding random numbers and treatment protocols) were sealed in numbered envelopes, managed by an independent researcher not involved in the study. Upon enrollment, envelopes were opened sequentially to reveal group allocation, resulting in 49 controls and 50 observation cases. The study protocol was approved by the Institutional Ethics Committee (Approval No.: 2022-016 ethically reviewed by Yinzhou No.2 Hospital), and written informed consent was obtained from all participants. No statistically significant differences between groups were found in general information ($p > 0.05$; Table 1), ensuring comparability. Inclusion criteria: conforming to diagnosis criteria of LDH in Practical Orthopedics [5], with magnetic resonance imaging (MRI)-confirmed disc herniation at L_4-L_5-S_1 levels; having typical symptoms (e.g., low back pain, lower limb numbness, restricted joint mobility); Oswestry Disability Index (ODI) score ⩾20, indicating functional impairment; aged 25–75 years; no history of psychiatric disorders; having complete clinical data; with disease duration of 2 to 4 years; visual analog scale (VAS) score >4; straight-leg raise test results showing positive before treatment. Exclusion criteria: suffering from congenital spinal deformities or dysfunction; having received lumbar surgery; suffering from severe dysfunction of heart, brain, liver, or kidneys; with complex spinal pathologies (e.g., discitis, thoracolumbar scoliosis); with comorbidities (e.g., spinal tuberculosis, spondylolisthesis, spinal tumors); with rheumatic/autoimmune disorders (e.g., rheumatoid arthritis, ankylosing spondylitis).

Table 1 Comparison of general information between the two groups [(mean ± standard deviation), n].

Groups	*n*	Age/years	Sex		Course of disease/months	BMI/(kg/m^2)	Painful area		
			Man	Woman			L_4	L_5	L_5S_1
Control	49	48.33 ± 8.23	27	22	26.71 ± 8.65	25.14 ± 6.38	14	18	17
Observation	50	47.62 ± 7.58	31	19	27.49 ± 8.13	24.63 ± 6.17	16	20	14
χ^2/t		0.449	0.485		-0.464	0.406	0.519		
p		0.655	0.486		0.643	0.685	0.771		

Note : BMI: body mass index.

2.2 Methods

Patients in both groups received routine treatments, incorporating correcting sitting posture, refraining from heavy physical work, sleeping on a firm mattress, traction and so on. For control group (mainly adopting kinesiology taping alone), initially, kinesiology tape (Suzhou BOGUAN Medical Supplies Co., Ltd.) was employed. Prior to application, the skin was disinfected. The location of lumbar disc herniation was confirmed via magnetic resonance imaging (MRI) and computed tomography (CT) scanning. The taping technique varied based on the affected level. L_4 Herniation ("I"-shaped taping method, Figure 1A): to be specific, the patient stood with arms crossed, the tape base was anchored at the posterior superior iliac spine (PSIS) region, together with the tail extended along the quadratus lumborum to the L_1 transverse process bilaterally. L_5 Herniation ("X"-shaped taping method, Figure 1B): the patient sat in a forward-leaning position, with the upper "anchor" fixed at the herniated vertebral level, with tails applied bilaterally under natural tension. $L_5 - S_1$ Herniation ("Y"-shaped taping method, Figure 1C): the patient sat upright with forward lean, the upper "anchor" was secured around the L_5-S_1, with tails extending along the erector spinae muscles. The tape was replaced every two days for four consecutive weeks.

The observation group received lumbar core muscle stability training in addition to kinesiology taping. The specific training methods were as follows: ① Knee-Hand Balance Training (Figure 2A): The patient maintained a quadrupedal kneeling position on a balance pad, contracted the abdomen, and stabilized the hips. The body's weight was supported on one hand and the contralateral knee, while the other limb separately extended forward and backward, the position of which was kept for 10 seconds before switching sides. ② Plank Exercise (Figure 2B): The patient lay prone with elbows bent and fists supporting the body on a balance pad. The hips were kept level with the shoulders, ensuring the scapulae remained posterior to the elbows; and the feet were spread shoulder-width apart. The patient maintained the position as long as possible for five consecutive times, allowing for a short relax when being tired. ③ Single Bridge Training (Figure 2C): The patient lay supine with a pillow placed between the legs. One leg was flexed while the other remained extended, and the patient performed hip extension and buttock lift, holding the position for 10 seconds before switching sides. ④ Double Bridge Training (Figure 2D): The patient lay supine with a pillow placed between the legs and both legs flexed, performing hip extension and buttock lift, holding the position for 10 seconds. ⑤Supine Leg Lift Training (Figure 2E): The patient lay supine with legs together and straightened. The legs were further lifted until the thighs were perpendicular to the ground and held for 5 seconds. ⑥ Yoga Ball-Assisted Exercises (Figure 2F): The patient lay with the abdomen and upper thighs on the ball, feet on the ground, and hands behind the head. The patient slowly extended the body and held the position for 5 seconds. ⑦ Suspension Training (Figure 2G): The patient lay supine with feet elevated and the lumbar spine in a neutral position. Core muscles were engaged to maintain a static suspended posture for 20 seconds, while the torso was then slowly rotated left and right, repeated 3 times per side, performed twice daily. The intensity was adjusted to a mild level of fatigue. The intervention period for both groups was 4 weeks.

Figure 1 Kinesiology Taping Technique. (A) "I"-shaped taping method; (B) "X"-shaped taping method; (C) "Y"-shaped taping method.

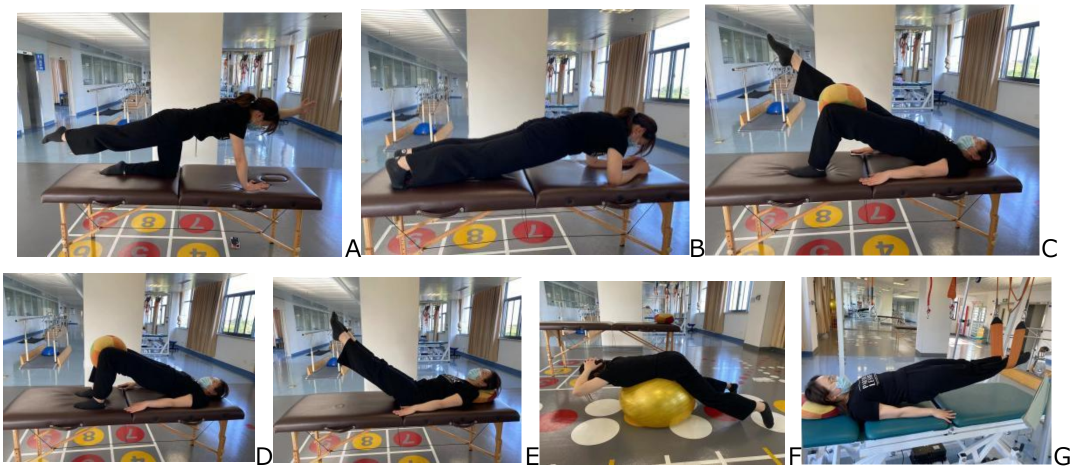

Figure 2 Lumbar core muscle stability training. (A) Knee and hand balance training; (B) Plank exercise; (C) Single bridge training; (D) Double bridge training; (E) Supine leg lift training; (F) Yoga ball-assisted exercises; (G) Suspension training.

2.3 Observation indicators

Before and after 4 weeks of treatment, the following assessments were conducted: visual analogue scale (VAS) was performed to evaluate pain intensity [6]; Japanese orthopaedic Association (JOA) score was used to assess clinical symptoms [7], with setting of 29 total score and higher scores indicating better recovery; Oswestry disability index (ODI) was used to evaluate lumbar function [8], with setting of score ranging from 0 to 50 and higher scores indicating more severe dysfunction; the ODI score was calculated as (actual score / maximum possible score) × 100%.

Before and after 4 weeks of treatment, surface Electromyography (sEMG) was performed using a MyoTrace™ 400 system (Noraxon, USA) to assess the biological characteristics of the lumbar extensor muscles during lumbar extension, including mean power frequency (MPF) and integrated electromyography (iEMG). In details, the patient sat with the dynamometer axis aligned with the L vertebra, rotating at 50°. Testing accessories and straps were securely fastened. The target muscles, namely, lumbar extensors were tested for concentric contraction at 60°/s angular velocity, recording the corresponding sEMG signals and biological parameters.

Before and after 4 weeks of treatment, maximum lumbar range of motion (ROM) in three directions (flexion, extension, and lateral flexion) was tested using the B-MOTIOR rehabilitation functional assessment and training system. Subjects were seated in the B-MOTIOR system with pelvis stabilized (Figure.3). Each direction was tested three times, and the average value was recorded.

During the treatment, the recurrence of adverse cutaneous reactions (pruritus, erythema, blistering, etc.) in both patient groups were observed and recorded during the treatment period. At the 1-month follow-up, patients were re-examined for LDH recurrence, defined as the reappearance of LDH symptoms after initial resolution (i.e., complete symptom relief with restored daily living and working capacity). The complication rate was calculated as (number of cases with complications / total cases) × 100%, while the recurrence rate was determined as (number of recurrent cases/total cases) × 100%.

Figure 3 Maximum range of motion of the lumbar spine was assessed using the Rehabilitation Functional Assessment and Training System (B-MOTIOR).

2.4 Statistical analysis

Data were analyzed using SPSS 20.0. Count data were expressed as n and compared using χ^2 test. If the total sample size was ⩾ 40 and the minimum expected frequency was ⩾ 1 but < 5, Yates' correction was applied. Normally distributed continuous variables were presented as mean ± standard deviation and compared between groups using the independent samples t-test. Non-normally distributed variables were expressed as median (interquartile range) [*M (P25–P75)*] and analyzed using the Mann-Whitney U test for between-group comparisons. For within-group comparisons over time, paired t-tests were used if the differences followed a normal distribution; otherwise, the Wilcoxon signed-rank test was applied. A two-tailed p-value < 0.05 was considered statistically significant.

3 Results

3.1 Follow-up

All 99 patients completed the follow-up with good compliance. The follow-up period was 1 month. VAS, JOA, and ODI scores and complication status were assessed via telephone questionnaire, while surface EMG values required hospital visits.

3.2 Comparison of lumbar function and pain between the two groups

Before treatment, there were no significant differences in VAS, JOA, and ODI scores between the two groups ($p > 0.05$). After 4 weeks of treatment, both groups showed significant decreases in VAS and ODI scores ($p < 0.05$), with the observation group showing significantly lower scores than the control group ($p < 0.05$). Both groups also showed significant increases in JOA scores ($p < 0.05$), with the observation group having significantly higher scores than the control group ($p < 0.05$). The improvement in the observation group was significantly greater than that in the control group ($p < 0.05$; Table 2-1 and Table 2-2).

Table 2-1 Comparison of lumbar function and pain between the two groups [(mean ± standard deviation), *M* (P_{25}～P_{75}), score].

Groups	*n*	VAS score		JOA score		ODI score	
		Before	After	Before	After	Before	After
Control	49	6 (6～7)	3 (2～3) *	12.8 ± 2.7	20.3 ± 2.2 *	26.3 ± 3.4	15.3 ± 2.9 *
Observation	50	7 (6～8)	2 (2～3) *	13.3 ± 3.1	23.9 ± 2.6 *	26.8±3.3	12.6 ± 2.4 *
t/*Z*		-1.431	-2.985	-0.853	-7.514	-0.811	5.083
p		0.152	0.003	0.395	< 0.001	0.419	< 0.001

Note: Compared with before treatment: * $p < 0.05$; VAS: visual analogue scales; JOA: Japanese orthopaedic associationscores; ODI: oswestry disability index; Before: before treatment; After: after 4 weeks of treatment.

Table 2-2 Comparison of lumbar function and pain improvement before and after treatment between the two groups [(mean ± standard deviation), *M (P25～P75)*, score].

Groups	*n*	VAS improvement	JOA improvement	ODI
Control	49	4 (2～5)	-7.53 ± 3.52	11.00 ± 4.66
Observation	50	5 (3～5)	-10.60±3.86	14.30 ± 4.15
t/Z		-2.768	4.130	-3.723
p		0.006	0.000	0.000

Note: Improvement = before treatment - after treatment; VAS: visual analogue scales; JOA: Japanese orthopaedic associationscores; ODI: oswestry disability index.

3.3 Comparison of sEMG values of lumbar extensor muscles between the two groups

Before treatment, there were no significant differences in the average power frequency and integrated EMG values of the lumbar extensor muscles between the two groups ($p > 0.05$). After 4 weeks of treatment, both groups showed significant increases in these values ($p < 0.05$), with the observation group having significantly higher values than the control group ($p < 0.05$). The improvement in the observation group was significantly greater than that in the control group ($p < 0.05$; Table 3-1 and Table 3-2).

Table 3-1 Comparison of surface EMG values of lumbar and dorsal extensor muscles between the two groups (mean ± standard deviation).

Groups	*n*	Average Power Frequency/Hz		Integrated myoelectric value/μV	
		Before	After	Before	After
Control	49	37.33 ± 5.23	42.58 ± 6.58 *	105.11 ± 18.29	114.75 ± 20.47 *
Observation	50	37.91 ± 5.98	46.74 ± 6.87 *	106.08 ± 19.38	124.49 ± 22.51 *
t		-0.516	-3.092	-0.257	2.264
p		0.607	0.003	0.797	0.026

Note: Compared with before treatment: * $p < 0.05$; Before: before treatment; After: after 4 weeks of treatment.

Table 3-2 Comparison of improvement of sEMG values of lumbar and dorsal extensor muscles between the two groups [M (P_{25}~P_{75})].

Groups	n	Average power frequency improvement/Hz	Integrated EMG improvement value/ μV
Control	49	-4 [(-12) ~ 1)]	-10 [(-20) ~ (-2)]
Observation	50	-8 [(-11) ~ (-4.25)]	-20 [(-34) ~ (-2.25)]
Z		-2.025	-2.104
p		0.043	0.035

Note: Improvement = before treatment - after treatment.

3.4 Comparison of lumbar functional activities between the two groups

Before treatment, there were no significant differences in lumbar flexion, extension, and lateral flexion activities between the two groups ($p > 0.05$). After 4 weeks of treatment, both groups showed significant improvements in these activities ($p < 0.05$), with the observation group having significantly higher scores than the control group ($p < 0.05$). The improvement in the observation group was significantly greater than that in the control group ($p < 0.05$; Table 4-1 and Table 4-2).

Table 4-1 Comparison of lumbar functional activities between the two groups [(mean ± standard deviation), °].

Groups	n	Anteflexion		Prolongation		Lateral flexion	
		Before	After	Before	After	Before	After
Control	49	27.55 ± 5.23	37.38 ± 5.88 *	18.75 ± 4.71	25.28 ± 5.21 *	19.25 ± 4.39	25.31 ± 4.91*
Observation	50	26.67 ± 5.41	40.85 ± 6.02 *	19.25 ± 4.13	27.89 ± 5.58 *	18.79±4.26	28.58 ± 5.44 *
t		0.827	-2.915	-0.564	-2.417	0.532	-3.155
p		0.410	0.004	0.574	0.017	0.596	0.002

Note: Compared with before treatment: * $p < 0.05$; Before: before treatment; After: after 4 weeks of treatment.

Table 4-2 Comparison of improvement of lumbar functional activity between the two groups [M (P_{25}~P_{75}) , °].

Groups	n	Forward bending improvement	Extension improvement value	Lateral flexion improvement
Control	49	-11 [(-16) ~ (-3)]	-7 [(-11) ~ (-2)]	-7 [(-10) ~ (-4)]
Observation	50	-15 [(-20) ~ (-9)]	-9 [(-13.75) ~ (-5.25)]	-10 [(-15.5) ~ (-7)]
Z		-2.371	-2.148	-2.499
p		0.018	0.032	0.012

Note: Improvement = before treatment - after treatment.

3.5 Comparison of complications and recurrence rates between the two groups

During treatment, there were no significant differences in skin pruritus rates between the two groups ($p > 0.05$). After 4 weeks of treatment, the recurrence rate in the observation group was significantly lower than that in the control group ($p < 0.05$; Table 5).

Table 5 Comparison of complications and recurrence rates between the two groups [*n* (%)].

Groups	*n*	Pruritus	Recurrence rate
Control	49	4 (8.16)	13 (26.53)
Observation	50	2 (4.00)	4 (8.00)
χ^2		0.200 *	5.975
p		0.655 *	0.015

Note: * Yates correction method.

4 Discussion

The pathogenesis of LDH is not fully understood but is believed to involve mechanical compression, chemical inflammation, and autoimmune responses targeting the intervertebral disc. Chemical inflammation and autoimmune responses are endogenous factors. Specifically, the nucleus pulposus can release chemical inflammatory factors that cause nerve root inflammation, leading to pain [9-10]. Clinically, diverse therapeutic modalities are available for LDH, tailored to individual variations in disease severity and progression stages. This study combined kinesiology taping with lumbar core muscle stability training to improve muscle strength, reduce pain, and enhance lumbar function in LDH patients.

The results showed that after treatment, the observation group had significantly better improvements in VAS, JOA, ODI scores, and lumbar ROM compared to the control group. This suggests that the combined therapy of kinesiology taping and lumbar core stability rehabilitation training can alleviate clinical symptoms in LDH patients. Kinesiology taping is a non-invasive rehabilitation technique that protects the musculoskeletal system and promotes functional recovery. It is characterized by safety and minimal side effects. The primary mechanisms of kinesiology taping include stabilization, relaxation, and stretching of soft tissues through varied taping techniques; reduction of pain receptor pressure via concentric taping, facilitating gate control theory-mediated pain relief by exciting spinal dorsal horn glial cells, thereby elevating pain thresholds; modulation of muscle contraction patterns and enhancement of local blood circulation, leading to muscle activation, improved joint mobility, and stability [11-12]. Currently, kinesiology taping is widely used in the management of various musculoskeletal pain disorders. The lumbar core stability rehabilitation training is based on the core stability muscle theory, targeting deep and superficial muscle groups in the anterior and posterior abdominal regions [13]. Core stability training involves both dynamic and static exercises, which enhances spinal stability through neuromuscular control systems, fine-tunes ligament tension to optimize spinal and pelvic alignment [14-15]. Through combined analysis of location of lumbar intervertebral disc and the function of core muscles. The lumbar intervertebral discs are located in the mid-trunk region, lacking direct skeletal support and relies on ligaments and muscles for stability. Nucleus pulposus herniation compresses nerve roots or the cauda equina, leading to lumbar pain, functional impairment, and radicular symptoms [16]. The core muscles serve as a kinetic bridge, stabilizing the spine and pelvis, increasing lumbar muscle strength, and ensuring proper force distribution during movement. Additionally, core stability training employs unstable surfaces to activate neuromuscular pathways and stimulate deep stabilizing muscles, thereby improving spinal biomechanics and lumbar function [17]. Research by Hu Guangqian [18] indicates that core muscles training can effectively improve patients' lumbar function and alleviate pain symptoms. Liu et al [19] found that kinesiology taping (muscle effect tape) can promote local blood circulation, and stability rehabilitation training of the lumbar core muscles can reduce muscle spasms and inhibit the secretion of pain-inducing substances. The combined use of these methods can facilitate the circulation and metabolism of pain-inducing factors, alleviating lumbar pain and improving lumbar function, which aligns with the findings of this study.

Mean power frequency (MPF) and integrated electromyography (iEMG) value are commonly used indicators for evaluating muscle biomechanical characteristics and are highly correlated with muscle strength. They can reflect muscle fatigue levels, with lower detection values indicating greater muscle workload intensity and increased susceptibility to fatigue [20]. The results of this study showed that after treatment, the MPF and iEMG values in the observation group were significantly higher than those in the control group, and the recurrence rate after treatment was significantly lower in the observation group compared to the control group, with no significant differences in complications between the two groups. This suggests that kinesiology taping technique combined with lumbar core muscle stability rehabilitation training helps improve muscle work vitality in patients with LDH, enhances muscle strength recovery, and has a good prognosis with safe and reliable efficacy. During the process of lumbar core muscle stability rehabilitation training, patients maintain a straight posture of the spine, which is beneficial for improving spinal stability and enhancing muscle fatigue resistance. The strength of the lumbar and back muscles is strengthened through repeated training, ensuring the restoration of balance in lumbar curvature and lumbar force distribution. Furthermore, benefiting from the activation of the motor units of the lumbar core muscles, patients' lumbar proprioception and promote muscle coordination could be improved, muscle spasms could be alleviated and nerve foot adhesions could be further released. Through continuous neuromuscular adaptation, it strengthens lumbar and back muscle strength [21]. Lumbar core muscle training improves spinal stability and muscle fatigue resistance by increasing the strength of the core muscles. When combined with kinesiology taping it further facilitates muscle contraction, reduces excessive muscle stretching, and enhances muscle strength, thereby mitigating muscle fatigue. In a study by Yu et al [22], core stability training was applied to patients with non-specific low back pain (NSLBP), demonstrating significant improvements in lumbar muscle endurance, coinciding with the results of the present study.

On a whole, the combined therapy of lumbar core muscle stability training and kinesiology taping technique can more effectively relieve muscle fatigue, contribute to alleviate lumbar pain and enhance lumbar functional activity, therefore it is superior to kinesiology taping technique alone in treating LDH. Also, efforts still should be made to address the limitations in this study. First, we were unable to evaluate the long-term therapeutic efficacy ,due to constraints in patient follow-up after treatment; variations in lifestyle habits may still have influenced outcomes such as recurrence rates and treatment effectiveness, despite the fact that patients were instructed on post-treatment precautions. In the future, we may delve into further studies on extending the follow-up duration to access long-term outcomes; enrolling only patients who can fully adhere to both treatment protocols and follow-up requirements; and delving into lifestyle factors (e.g., daily habits, occupational demands), so as to analyze their potential impact on treatment efficacy and recurrence rates.

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Not applicable.

Conflicts of Interest

All authors declare that the research was conducted in the absence of any commercial or fnancial relationships that could be construed as a potential confict of interest.

Author Contributions

Y.L. and L.L. conceptualized the trial with support from co-authors. Y.L. and L.L. participated in creating the study design. Q.C. made the first draft of the manuscript. Y.L., L.L. and Q.C. participated in creating the statistical analysis plan. All authors reviewed and revised the manuscript critically for important intellectual content. All authors reviewed the final manuscript as submitted. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The study protocol was approved by the Institutional Ethics Committee (Approval No.: 2022-016 ethically reviewed by Yinzhou No.2 Hospital), and written informed consent was obtained from all participants.

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Availability of Data and Materials

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

Supplementary Materials

Not applicable.

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