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Original Article

Curative effects on muscle function and proprioception in patients with chronic lumbar disk herniation using isokinetic trunk muscle strength training

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Abstract: The aim of this study was to evaluate the curative effects on muscle function and proprioception in patients with chronic lumbar disk herniation (LDH) using two kinds of kinesitherapies: isokinetic trunk muscle strength training and core muscle training. Eighty patients with clinical features of lumbar disk herniation were randomly divided into treatment and control groups (40 patients in each group). All participants were given routine rehabilitation treatment, including interferential electrotherapy, microwave therapy, lumbar traction treatment, and other physical therapies. The treatment group received isokinetic trunk muscle strength training, while the control group received core muscle training, both lasting for 8 weeks, three times per week. Improvement in patient motor and sensory function, before and after treatment, was evaluated using lower back pain standard scoring criteria of Japanese Orthopedic Association (JOA), Oswestry disability index (ODI), and visual analogue scale (VAS). After 8 weeks of continuous training, trunk muscle strength evaluation indexes of the patients in the two groups significantly increased, compared to before treatment. Moreover, JOA, ODI and VAS scores suggested that both treatments could significantly improve lumbar function concerning trunk muscle strength, rehabilitation evaluation of lumbar function, and lumbar proprioception assessment. Furthermore, the ontology sense test indicated that the absolute error value of proprioception was reduced after both routine rehabilitation treatment and isokinetic trunk muscle strength training treatment. In conclusion, this study showed that isokinetic trunk muscle strength training could improve proprioception in patients with chronic lumbar disk herniation. It also enhanced muscle function, compared with core muscle training.

Keywords: Core muscle training, chronic lumbar disk herniation (LDH), isokinetic trunk muscle strength training

Introduction

Lumbar disk herniation (LDH) is a common spinal degenerative disease with various clinical manifestations, including spinal stiffness and stenosis, nerve root pain, and prolapse LDH. It not only influences health and quality of life, but also causes a heavy burden of medical and social costs [1]. Studies have proven that decreases in lumbar muscle strength or imbalances caused by degenerative lumbar spine are vital factors of LDH onset or recurrence [2]. Some scholars have pointed out that intensive trunk muscle training can optimize spine stability, control segmental motion, and ease backaches and other symptoms [3]. Designing an effective rehabilitation training plan to relieve clinical symptoms and improve lumbar vertebral function has been a hotspot in the field of rehabilitation medicine and sports medicine. Currently, there are many kinds of LDH rehabilitation therapies, including sports therapy, physical factor therapy, traction therapy, and thermotherapy. Although all kinds of treatments display certain therapeutic effects, LDH patients easily relapse and need treatment designed for a long time. After numerous scientific validation and clinical patient selections, isokinetic trunk muscle strength training and core muscle training have gained maximum attention due to significant curative effects.

Trunk flexion and extension is governed by sensory (ligaments), neural, active (muscle), and passive (bones) structures, essential for the maintenance of spine balance and stability [4]. Altered trunk flexion-extension strength has been reported be related to low back disorders through increasing lumbar kinematic variability during gait [5, 6]. Therefore, the purpose of this study was to compare isokinetic trunk muscle strength training with core muscle training regarding curative effects on muscle function and proprioception in LDH patients.

Materials and methods

Inclusion criteria of subjects

(1) Symptoms: reiterative pain in the waist or (and) lumbosacral portion, waist stiffness, and sciatica (radiating pain from the waist to hips, behind thighs, and lateral legs till feet); (2) Signs: lumbar scoliosis, waist limitation of motion, tenderness of supraspinous ligaments in pathologically changed vertebral space and spasm of sacrospinous muscle, positive straight leg raise test, paresthesia of corresponding nerve root distribution region, muscle weakness, and dysreflexia; (3) Imaging examination: x-ray, CT, and MRIs showing positive disk herniation changes; (4) Course of disease: more than 3 months; and (5) General conditions: ages ranging between 20 and 65 years, vital signs stable, and no other serious system diseases. This study was approved by the Ethics Committee of Shanghai Gongli Hospital and was conducted according to the Declaration of Helsinki. Informed consent was provided by all patients.

Exclusion criteria of subjects

(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; and (4) Patients with a disease of the cardiovascular system, liver, kidneys, and blood, immune system disorders, metabolic diseases, and cognitive dysfunction.

Based on these criteria, 80 patients with lumbar intervertebral disk protrusion in the Separtment of Rehabilitation Medicine (Shanghai Gongli Hospital, Shanghai, China), from October 2015 to June 2016, were selected and randomly divided into isokinetic trunk muscle strength training group (referred to as the treatment group) and core muscle training group (referred to as the control group), according to a random number table (40 patients in each group). The treatment group included 17 male and 13 female patients (age 20-65 years, average age 43.15 ± 9.64 years). Disease course was 3-10 months, with an average of 5.37 ± 1.33 months. The control group included 18 male and 12 female patients (age 20-65 years, average 41.93 ± 8.98 years). Disease course was 3-10 months, with an average of 5.10 ± 1.32 months. No statistically significant differences in clinical data were found between the two groups of patients before treatment (P>0.05). Data proportionality was consistent and comparable. Patient basic information is shown in **Table 1**.

Rehabilitation methods

Routine rehabilitation treatment methods included interferential electrotherapy, microwave therapy, and lumbar traction. Specific methods were as follows:

Interferential electrotherapy: The frequency was 4000 Hz (4000 ± 100 Hz), according to patient tolerance and regulation. Each treatment lasted for 15 minutes, once a day, five times per week for 8 weeks.

Microwave: The frequency was 2450 ± 50 MHz. The power was 50 W. Treatment lasted for 12 minutes each time, once a day, 5 times per week for 8 weeks.

Lumbar traction: Patients were placed in the supine position on a traction bed with bent knees and coxa. Tensile strength was 30% of the body weight and gradually increased to no more than 60% of body weight, according to the situation. Treatment lasted for 20 minutes each time, once a day, 5 times per week for 8 weeks. Patients in the treatment group were provided isokinetic trunk muscle strength training. The Biodex isokinetic trunk muscle strength training evaluation system (Biodex Multi-Joint System 4, Biodex Corporation, USA) was adopted and accessories of seat configuration with flexion muscle trunk strength training model were used. The centripetal/centripetal training mode

Table 1. Patients basic information ($\overline{x} \pm s$)

Group	n	Sex		Age (year)	Couse of disease (Moth)	BMI (kg/m²)		Affected side		Type			
		Male	Female			Male	Female	Left	Right	Bulg	Protruded	Free form	Schmorl nodule
Treatment group	40	17	23	43.15 ± 9.64	5.37 ± 1.33	22.75 ± 3.36	20.32 ± 1.36	18	22	35	2	0	3
Control group	40	18	22	41.93 ± 8.98	5.10 ± 1.32	23.01 ± 4.26	21.15 ± 2.31	21	19	36	1	0	3
F		0.049 (X^2)		0.495	0.486	1.136	1.214	0.456 (X^2)					
P		0.054 (P)		0.484	0.488	0.191	0.213	0.51 (P)					

Table 2. Trunk flexor muscle function at 60°/s angular velocity of two groups of patients before and after treatment ($\overline{x} \pm s$)

Item	PT(N-M)		PT/BW (N-M)		TW (J)		AP (J)	
	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)
Flexor								
Pre	62.64 ± 17.17	61.25 ± 15.52	92.27 ± 25.04	89.96 ± 22.62	228.90 ± 55.53	234.93 ± 59.33	16.69 ± 3.51	15.69 ± 2.95
Post	99.43 ± 23.44[a,b]	69.07 ± 14.70[a]	113.16 ± 30.52[a,b]	93.63 ± 20.94[a]	378.13 ± 71.37[a,b]	257.88 ± 63.53[a]	27.65 ± 6.17[a,b]	19.324 ± 4.05[a]
T	19.751	5.094	21.593	2.162	15.071	3.396	16.486	14.087
P	<0.001	<0.001	<0.001	0.037	<0.001	0.002	<0.001	<0.001
Extensor								
Pre	81.67 ± 21.49	79.09 ± 18.31	117.58 ± 30.34	114.74 ± 26.62	314.05 ± 45.95	303.72 ±37.89	24.18 ± 3.61	23.53 ± 2.79
Post	148.32 ± 37.98[a,b]	84.60 ± 19.12[a]	163.18 ± 30.29[a,b]	119.87 ± 20.01[a]	468.97 ± 77.05[a,b]	332.14 ± 37.89[a]	35.37 ± 6.98[a,b]	28.06 ± 4.61[a]
T	17.236	3.718	14.620	3.724	23.20	6.553	16.66	7.802
P	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001

Compared with pretreatment, [a]$P<0.05$; compared with the control group, [b]$P<0.05$.

was selected: 60°/s × 10, 120°/s × 20, and 180°/s × 30 with two sets. Training was performed with each angular velocity pausing for 1 minute and resting for 3 minutes between sets. The entire training lasted for 8 weeks, 3 times per week. Patients in the control group were provided core muscle training, including three motions as a dorsal bridge, ventral bridge, and lateral bridge. (1) Basic motion of dorsal bridge: patients were placed supine with arms crossed across the chest and knees bent at 90°. Head, shoulders, and feet acted as support. Patients strengthened the waist, shrank the abdomen, and raised the hips slowly. Finally, the trunk, pelvis, and bilateral thighs formed a straight line. Patients were kept in this posture for 15-20 seconds, then slowly restored to their original position. This was repeated three to five times. Advanced dorsal bridge motion: patients raised their left leg (straightened knee) on the basic motion, with bilateral legs parallel. Patients were kept in this position for 15-20 seconds and slowly restored to their original position. This was repeated three to five times. The same procedure was followed for the right leg. (2) Basic motion of ventral bridge: patients were placed prostrate with bending elbows and knees at 90°. Elbows and knees acted as a support on the bed. Patients strengthened the waist, shrank the abdomen, and raised the hips slowly. Finally, the trunk, pelvis, and bilateral thighs formed a straight line. Patients were kept in this posture for 15-20 seconds, then slowly restored to their original position. This was repeated three to five times. Advanced ventral bridge motion: Based on basic motion of ventral bridge, the patients were supported with the right elbow and left knee. The left arm and right leg were then raised at the same time. The body was kept straight for 15-20 seconds and then slowly restored to its original position. The same procedure was followed for the other side. This action was repeated three to five times. (3) Basic motion of lateral bridge: patients were placed on the right side in a straight line from trunk to thighs. The bilateral knee joints were slightly bent. The right elbow and right knee acted as a support. Patients raised their trunk and hips, strengthened their abdomen, and placed their left hand on the left side of the body. The body and floor formed a triangle. Patients maintained body balance for 15-20 seconds, after which the body was restored to its original position. This action was repeated three to five times. The same procedure was followed for the other side. Advanced side bridge motion: Based on basic motion, patients used straight instead of bent knees. The right elbow and right knee acted as a support. Patients raised their trunk and hips and then strengthened their abdomen by placing their left hand on the left side of the body. Patients maintained body balance for 15-20 seconds, then the body was restored to its original position. This action was repeated three to five times. These three actions defined one group. Patients were trained on two groups each day, five times a week, for 8 weeks.

Rehabilitation evaluation criteria

Rehabilitation efficacy was evaluated at the beginning of selection and the end of 8-week training. The following assessments were made by a therapist that was blinded to grouping and therapy progress.

Muscle strength assessment

American Biodex isokinetic trunk muscle strength training evaluation system 4 (Biodex Corporation) was used. Quality testing was done before using the dynamometer. After quality control, the patients sat straight. The power dynamometer axis was aligned to patient torso's L5-S1 and the upward side of the dynamometer axis was aligned to the scapula. Patient thighs were fixed to the mount by a bandage, with knee joints in a flexed position before the mount. The posture was fixed with lower back flexion at 90°. It was necessary to ease patient nervousness and divert their attention during testing. Patients clasped their hands on both sides of the handle in formal testing. Flexion and extension ranges were set using software. Before setting the angular velocity as 60°/s × 10, 120°/s × 15, and 180°/s × 20, patients were notified to perform flexion and extension stretching activity five times, then fully flex and extend their lumbar spine. Test indexes were as follows: (1) Peak torque (PT), indicating maximum muscle strength; (2) Relative peak torque (PT/BW), the best indicator for evaluating muscle strength of different body weights; (3) Total work (TW), representing total work and reflecting the function of muscles; and (4) Average power (AP), which stands for average power of the muscles and is an evaluation index relative to total work.

Rehabilitation evaluation of lumbar function

JOA, ODI and VAS scores were adopted to assess improvement function of patients. Japanese Orthopedic Association (JOA) scores included 9 points for subjective symptoms (3 points for lumbago, 3 points for skelalgia or numb pain, and 3 points for walking function), 6 points for objective signs (2 points for raising straight leg, 2 points for sensory disability, and 2 points for muscle strength), and 14 points for limited mobility in daily life (including turn over on clinostatism, standing, washing, leaning forward, sitting for 1 hour, lifting, walking, and so forth). The full score was 29 points [7]. A higher score meant less severe symptoms and a lower score meant more severe symptoms. Oswestry disability index (ODI) scores [8] comprised 10 parameters, including intensity of pain, self-reliance, loading goods, walking, standing, interfering sleep, sexual life, social life, and travel problems. Each question had six options, with a maximum score of five points. The first question score was 0 point and the last option score was 5 points. Higher scores indicated more serious dysfunction. For visual analogue scale (VAS) [9] scores, a 10-cm horizontal line was drawn on the paper. One end of the horizontal line stood for 0, which meant painless. The other end stood for 10, which meant severe pain. The middle section meant different levels of pain. Patients were told to mark on the horizontal line, showing pain levels.

Lumbar proprioception assessment

Biodex isokinetic trunk muscle strength training evaluation system 4 (Biodex Corporation) was used in lumbar proprioception testing [10]. Patient positions in testing and at preparation were determined by muscle strength testing. After preparation, the patients were given a starting position and a target position. The starting position was an upright position for 90° and the target position of flexion for 30° (120°) and extension for 15° (75°). After setting start and target positions, patients wore an eye mask and earmuffs to eliminate visual and auditory interference and influence. Testing processes were interpreted in detail so that the patients were familiar with them. Testing was carried out when preparations were done. Testers helped patients forward bend to 110° from the initial position. The patients stayed for 5 seconds in the target position. They were told to remember the position and then returned to the starting position. After 10 seconds of rest, the patients actively moved to the target position with a button on their hand. They pressed the button on arriving at the target position. The dynamometer recorded the actual position at the same time. This test was completed in 1 minute. It was performed three times. The average actual angle was recorded three times and absolute error angle (absolute error of actual angle value to the scheduled target angle) was calculated. The error angle of extension for 80° was tested using the same methods.

Statistical analysis

SPSS version 17.0 software (SPSS, IL, USA) was used for statistical analysis. Measurement data are expressed as mean ± standard deviation ($\overline{x} \pm s$). Repeated measurement ANOVA was used to compare differences between treatment and control groups before and after treatment. X^2 test was used to analyze categorical data. The significance level was set as $\alpha = 0.05$. *P* values less than 0.05 indicate statistically significant differences.

Results

Evaluation of isokinetic trunk muscle strength

After 8 weeks of continuous training, trunk muscle function in the two groups significantly increased, compared with before treatment, at three different angular velocities (60°/s, 120°/s, and 180°/s), which were measured by peak torque (PT), relative peak torque (PT/BW), total work (TW), and average power (AP) ($P < 0.05$). There were no significant differences before and after rehabilitation training in both groups before 60°/s angular velocity measured with PT, PT/BW, TW, and AP clinical values ($P > 0.05$). After 8 weeks of trunk isokinetic training, flexor and extensor trunk muscle function indexes were significantly higher, compared with those of control group (core muscle training) ($P < 0.05$), indicating that the treatment group improved more prominently (**Table 2**). The two groups significantly increased trunk muscle function indexes, compared with those before treatment, at 120°/s and 180°/s velocity. Moreover, after 8 weeks of treatment, patients receiving trunk isokinetic training had significantly higher trunk muscle function index-

Table 3. Trunk flexor muscle function at 120°/s angular velocity of two groups of patients before and after treatment ($\bar{x} \pm s$)

Item	PT (N-M)		PT/BW (%)		TW (J)		AP (J)	
	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)
Flexor								
Pre	58.42 ± 16.97	56.73 ± 15.62	87.33 ± 24.46	84.77 ± 21.34	473.19 ± 75.56	455.87 ± 74.28	37.02 ± 4.09	35.12 ± 4.91
Post	79.31 ± 20.57[a,b]	62.89 ± 17.31[a]	101.87 ± 24.64[a,b]	88.25 ± 19.12[a]	622.93 ± 76.27[a,b]	482.98 ± 80.43[a]	48.53 ± 9.12[a,b]	39.23 ± 7.96[a]
T	9.598	20.442	9.384	2.291	16.23	3.259	10.624	4.927
P	<0.001	<0.001	<0.001	0.027	<0.001	0.002	<0.001	<0.001
Extensor								
Pre	73.90 ± 17.99	71.38 ± 14.84	106.63 ± 21.19	109.50 ± 18.23	483.26 ± 70.39	493.98 ± 77.19	47.65 ± 6.86	49.55 ± 6.71
Post	123.7 ± 31.81[a,b]	88.97 ± 16.39[a]	130.01 ± 17.88[a,b]	114.01 ± 17.80[a]	652.78 ± 47.08[a,b]	511.14 ± 72.55[a]	59.73 ± 8.97[a,b]	53.30 ± 8.69[a]
T	14.916	8.96	8.192	2.971	14.69	2.406	22.29	2.509
P	<0.001	<0.001	<0.001	0.005	<0.001	0.018	<0.001	0.016

Compared with pretreatment, [a]*P*<0.05; compared with the control group, [b]*P*<0.05.

Table 4. Trunk flexor muscle function at 180°/s angular velocity of two groups of patients before and after treatment ($\bar{x} \pm s$)

Items	PT (N-M)		PT/BW (%)		TW (J)		AP (J)	
	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)	Treatment group (*n* = 40)	Control group (*n* = 40)
Flexor								
Pre	54.60 ± 14.62	53.10 ± 12.85	80.42 ± 21.05	79.80 ± 18.12	802.86 ± 89.25	796.68 ± 68.41	80.58 ± 8.89	79.97 ± 7.46
Post	69.18 ± 17.11[a,b]	57.21 ± 12.68[a]	93.25 ± 24.40[a,b]	82.24 ± 17.64[a]	1103.7 ± 132.7[a,b]	833.69 ± 82.70[a]	117.8 ± 15.93[a,b]	82.12 ± 9.02[a]
T	22.505	8.081	14.178	2.409	37.83	6.23	25.771	3.362
P	<0.001	<0.001	<0.001	0.021	<0.001	<0.001	<0.001	0.002
Extensor								
Pre	67.76 ± 1492	65.99 ± 14.92	98.99 ± 19.95	96.15 ± 18.86	945.80 ± 62.80	933.21 ± 78.83	104.6 ± 6.39	103.8 ± 8.10
Post	93.89 ± 21.57[a,b]	71.79 ± 17.16[a]	115.9 ± 23.30[a,b]	99.43 ± 19.51[a]	1216.1 ± 83.81[a,b]	958.48 ± 80.61[a]	139.6 ± 9.88[a,b]	106.2 ± 9.15[a]
T	9.727	8.081	31.804	2.136	58.098	51.297	49.649	2.107
P	<0.001	<0.001	<0.001	0.036	<0.001	<0.001	<0.001	0.042

Compared with pretreatment, [a]*P*<0.05; compared with the control group, [b]*P*<0.05.

Table 5. F/E ratio at different angular velocities before and after treatment ($\overline{x}$ ± s)

Group	Pre-post	60°/s	120°/s	180°/s
Treatment group (*n* = 40)	Pre	0.77 ± 0.06	0.78 ± 0.08	0.81 ± 0.08
	Post	0.65 ± 0.02[a,b]	0.64 ± 0.01[a,b]	0.63 ± 0.11[a,b]
T		-10.961	-10.586	-8.344
P		<0.001	0.001	<0.001
Control group (*n* = 40)	Pre	0.77 ± 0.07	0.77 ± 0.09	0.79 ± 0.08
	Post	0.83 ± 0.15	0.72 ± 0.11[a]	0.74 ± 0.02[a]
T		3.421	-2.684	-3.834
P		0.054	0.011	<0.001

Compared with pretreatment, [a]*P*<0.05; compared with the control group, [b]*P*<0.05.

Table 6. Assessment of JOA, ODI, and VAS before and after treatment ($\overline{x}$ ± s)

Groups	Pre-post	JOA	ODI	VAS
Treatment group (*n* = 40)	Pre	16.80 ± 2.23	27.06 ± 2.94	6.45 ± 0.96
	Post	24.05 ± 2.15[a,b]	10.55 ± 1.45[a,b]	2.88 ± 0.76[a,b]
T		37.763	-32.832	-22.389
P		<0.001	<0.001	<0.001
Control group (*n* = 40)	Pre	15.98 ± 2.37	26.63 ± 2.48	6.05 ± 0.93
	Post	20.02 ± 2.70[a]	18.33 ± 4.03[a]	4.03 ± 1.05[a]
T		12.894	-16.383	-17.464
P		<0.001	<0.001	<0.001

Compared with pretreatment, [a]*P*<0.05; compared with the control group, [b]*P*<0.05.

es at 120°/s and 180°/s velocity, compared with patients receiving core muscle training (P<0.05) (**Tables 3**, **4**). Patients in the treatment group improved more obviously (P<0.05). After 8 weeks of training, the F/E ratio was significantly lower, compared with before treatment. The treatment F/E ratio of the treatment group reduced more obviously (P<0.05) and basically met the normal range (**Table 5**).

Rehabilitation evaluation of lumbar function

JOA (Japanese Orthopedic Association), ODI (Oswestry disability index), and VAS scores (visual analogue scale) of patients suggested that both training methods could dramatically improve lumbar function (P<0.05), while improvement in the treatment group was more obvious (P<0.05) (**Table 6**).

Lumbar proprioception assessment

After 8 weeks of training, results of isokinetic trunk proprioception dynamometer indicated that both treatments could significantly improve patient ontology (P<0.05). Improvements in trunk muscle and lumbar function were more obvious in the treatment group, compared with the control group (P<0.05).

Discussion

Lumbar disk herniation (LDH) results from the overuse or misuse of the lumbar spine, leading to disability and impacting quality of life. LDH patients suffer from low backaches, sciatica, intervertebral disk or ligament deformation, and lumbosacral nerve damage. One important mechanism of LDH is declined strength of lumbar muscles, thereby causing a decrease in lumbar spinal stability [11, 12]. Blood circulation disorders can induce the release of inflammatory mediators, causing lumbago and waist dysfunction [13]. A number of researchers have attempted to improve waist muscle strength in patients with low back pain and lumbar intervertebral disc protrusion [14-16]. Therefore, lumbar muscle training has been used for herniated lumbar intervertebral disk treatment due to its curative effects [17]. Isokinetic trunk muscle strength training is an objective safety and repeatability testing and muscle strength training method. It has been widely used in sports fields, sports research, and rehabilitation fields. The present study focused on its effects of relieving clinical symptoms and improvement of lumbar vertebral function. The effects of muscle strength training on rehabilitation of LDH were mainly reflected in the following aspects. First, muscle strength training LDH patients can stimulate the central nervous system, promote the signal transduction of muscle fibers and enhance central motor conduction, and improve the excitability and responsiveness of the nerves, thereby promoting the contraction of active and antagonistic muscles simultaneously. Second, muscle strength training can promote coordination and stability of the lumbar muscles and enhance the stability of the spine, thereby protecting the lumbar spine through enhancing function of the muscle groups. Third, muscle strength training can help improve and restore lumbar function in patients with LDH. Active muscle contractions can favor the activity of lumbar intervertebral disc by small joints and increase waist muscle strength to promote lumbar muscles around the spine, ligaments, and functional recovery, thereby eliminating all kinds of movement disorders due to pain. Fourth, muscle strength training can relax nerve root adhesion and promote the recovery of nerve function. Constant stretching exercises simulate the efficacy of lumbar traction for LDH patients with active flexion, restore the physiological lordotic curvature of lumbar spine, and reduce back pressure on intervertebral discs, thereby relieving nerve root compression and adhesion. Therefore, isokinetic muscle strength training has demonstrated improvement on motor and proprioceptive function of the lumbar muscles in LDH patients.

Overstress of lower back muscle fibers on one side or partial muscles leads to pain aggravation or chronic pain. This may cause a local functional disturbance, besides affecting body balance and function. Isokinetic muscle strength testing and training dynamometer can provide compliance resistance to actual muscle contractility. Consequently, the limbs and trunk can bear maximum resistance at different angular velocities and muscles can produce maximum tension and torque output. Isokinetic muscle strength training has advantages of isotonic and isometric contraction, which can strengthen damaged muscles and improve coordination and stability of local muscles. Optimizing asymmetric phenomena of back muscles bound by the vertebral column can improve the function of partially damaged muscles and abate local pain [18]. Patients should sit while undergoing isokinetic muscle strength training, then proceed to flexion and extension. The treatment process not only relieves compression of protruded intervertebral discs to nerve roots but also provides lumbar traction. This makes isokinetic exercise a safe and efficient training method in enhancing the strength of waist core muscles. Waist core muscle strength refers to the waist, pelvis, and hips as the primary skeleton. Deep-seated and superficial core muscle coordination maintains spinal bending capacity. Isokinetic trunk muscle strength training enhances spinal vertebral stability, alleviates oppression of intervertebral disk nerves and blood vessels, and eases back pain. Isokinetic muscle strength training is also a kind of proprioception training in repetitive flexion and extension, stimulating sensors in muscles and tendons at different angular velocities. Sensors can feel traction and contraction of muscles, further relieving clinical symptoms.

After 8 weeks of isokinetic muscles strength training (treatment group) and core muscle group training (control group), muscle strength of patients in the treatment group improved more obviously ($P<0.05$), compared with the control group. Core muscle group training has been reported by many researchers to improve patient muscle strength significantly. Isokinetic muscle strength training means correspondingly adjusted imposed resistance according to changes in muscle strength in movement at a predetermined angular velocity. Exercises based on the preset angular velocity only increase muscle strength in motion and raise torque output without any changes in angular velocity. After 8 weeks of training, muscle strength tests of patients indicated a significant improvement in all kinds of motion and quality of life.

Proprioception plays an important role in maintaining the functional stability of joints and physical space perception [19, 20]. Studies have shown that weak or lost lumbar proprioception has been closely related to waist dysfunction. Reconstruction of lumbar proprioception training is essential for rehabilitation treatment of patients with lumbar disorders [21, 22]. Normal waist proprioception is crucial in maintaining lumbar functional stability. Its deficiency and weakness can cause a decline in the accuracy of trunk movement and position and dynamic control, further influencing the stability of the lumbar spine and causing lumbago, repeatedly [23]. Therefore, effective rehabilitation treatment to enhance patient proprioception is good for the stability of lumbar spine and recovery of various functions. After 8 weeks of training, patients in the treatment group had not only obviously enhanced muscle strength but significantly improved proprioception, compared with the control group ($P<0.05$). This improved proprioception may have been due to the fact that isokinetic muscle strength training improves muscle strength more obviously and makes stronger stimulation on surrounding muscles and tendons by repetitive flexion and extension movements.

Pain, along with declined muscle strength and loss of coordination control, reduces quality of life in LDH patients. The present study showed that 8 weeks of training isokinetic muscle strength could increase lumbar spinal stability in patients, as well as relieve pain and improve the function of the lumbar spine. JOA scores suggested that self-consciousness, clinical symptoms, and daily life movement obviously improved in patients of the two groups. However, the index of patients in the treatment group was statistically higher than that in the control group ($P<0.05$). ODI scores indicated that the quality of daily life improved to some extent in the two groups. In contrast, the index in the treatment group improved more obviously ($P<0.05$). VAS scores indicated that both two groups significantly reduced clinical self-conscious perception of pain after treatment. VAS scores of patients receiving isokinetic muscle training were statistically lower than those in the control group after training ($P< 0.05$). Repeatable isokinetic muscle training of the waist might accelerate blood circulation and metabolism of inflammatory substances around the lumbar spine, thus easing pain in the waist.

In conclusion, isokinetic trunk muscle strength training is more effective in improving muscle function and proprioception in LDH patients than core muscle training. Moreover, simultaneous application of the dynamometer makes isokinetic trunk muscle strength training more secure through adjusting training plans according to patient clinical symptoms. Future studies should explore its efficacy by combining isokinetic trunk muscle strength training with waist core muscle training on the basis of conventional rehabilitation, thereby shortening treatment times for patients with lumbar disk prolapse during pain.

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Disclosure of conflict of interest

None.

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