

The Efficacy of Spinal Decompression via DRX3000 Combined with a Spinal Mobilization and a Lumbar Stabilization Exercise Program for Patients with Discogenic Low Back Pain

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Abstract. [Purpose] The purpose of this study was to determine the effects of motorized spinal decompression using the DRX3000 system (Axiom Worldwide, Tampa, FL, USA) combined with spinal mobilization as well as lumbar stabilization exercises on patients with discogenic low back pain (LBP). [Subjects] A total of 30 adults with discogenic LBP (mean age, 34.06 ± 6.41 years; age range, 28–48 years; 14 males, 16 females) volunteered to participate in this study. [Methods] A 4-week course of spinal decompression treatment combined with motorized flexion-distraction mobilization and lumbar stabilization exercises were administered to the participants for 6 days per week for the first two weeks, and four times per week for two additional weeks. The entire treatment consisted of 20 visits over a 4-week period. Comparisons of changes in the Oswestry Disability Index (ODI) and straight leg raise (SLR) test at pre-intervention, after 10 treatment sessions, and at discharge (after 20 treatment sessions) were analyzed. [Results] There were significant improvements in the outcome measures of ODI score and SLR test after 10 and 20 sessions of spinal decompression treatment combined with spinal mobilization and lumbar stabilization exercises as compared with the pre-intervention. [Conclusion] Spinal decompression treatment combined with spinal mobilization and lumbar stabilization exercises significantly improved the clinical outcome measures of ODI score and SLR test in patients with LBP secondary to intervertebral disc herniation.

Key words: Low back pain, Spinal decompression therapy, Spinal mobilization

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INTRODUCTION

Chronic low-back pain (LBP) is common in the general population and is considered to be a significant problem in industrialized countries¹⁾. Lifetime prevalence of LBP varies ranging from 61–83% in younger age groups and 53–75% in older groups²⁾. Symptoms often recur within 1 year in

60–80% of the population, even if the original presentation resolves in most cases; some patients suffering from LBP may experience chronic, unremitting symptoms³⁾ including sciatic conditions, which may exist in one quarter of those experiencing LBP⁴⁾. LBP is also an important economic issue and a challenge to the health care systems of developed countries, as they result in

major medical costs. For example, in the United States, the cost attributed to LBP is estimated to be more than \$100 billion annually^{5,6}.

There are many mechanical issues in the lower back which may lead to LBP, including injury to muscles and ligaments in the lumbosacral region, facet joint or sacroiliac joint arthropathy or discogenic disease due to disc degeneration⁷. Discogenic disease typically presents as pain in the lower back, buttocks, and hips and complaints of weakness, numbness or tingling, radicular pain, and claudication^{8,9}. Biomechanical compromise of the lumbar motion segment caused by a degenerative change in an intervertebral disc may lead to a decrease in nucleus pulposus pressure in persons with chronic LBP^{10,11}. The resulting compressive stress would be transferred from the nucleus to the posterior annulus leading to a 34% fall in nucleus pulposus pressure¹². It has been also shown that the tensile modulus, the Poisson's ratio, failure stress, and strain energy density of the annulus fibrosus are also negatively affected by disc degeneration¹³. Thus, structural defects in the annulus fibrosus could result in a failure at lower loads and further structural disruption, and this phenomenon has been shown to lead to LBP¹³. Although the degenerative intervertebral disc problem is difficult to treat without recourse to surgery, except for the most moderate cases¹⁴⁻¹⁷, due to the structural nature of the disease¹⁸, many noninvasive treatment options such as physical therapy, exercises, medications, back school, manipulation, or acupuncture have been developed to reduce neurological symptoms as well as leg or back pain related to disc disease or to enhance disc physiology in the hopes of retarding or reversing disc degeneration¹⁹⁻²⁴.

One of the treatment options is axial traction, an attempt to relieve LBP by acting on the disc and nerve roots, which can be applied in a variety of ways. These applications include traction via a motorized pulley (motorized traction), manual traction by a therapist (manual traction), traction delivered by the patient exerting traction force via pulling or pushing on bars at the head of a table with the patient in Fowler's position on a specially designed table (autotraction), and through a suspension apparatus (gravitational traction)²⁵. In all cases, with the exception of the motorized lumbar traction, it is difficult to maintain the treatment for a certain period of time due to fatigue of the patient or therapist as well as the patient's

intolerance to the position and/or the force applied²⁶. Therefore, the use of motorized lumbar traction by encompassing a split table to eliminate the friction force between the bed and the body has now become more common in clinical practice because of its greater success at standardization of repeatability in trials²⁵. When traction is applied, pull force of traction may elicit a protective proprioceptive response resulting in contraction of the paravertebral muscles, which could reduce the traction force²⁶.

Recently, several axial decompression devices newly developed for non-surgical treatment of chronic (and/or acute) LBP have been introduced to the market and are being widely used in a variety of clinical settings. These lumbar traction systems include the DRX3000/DRX9000 (Axiom Worldwide, Tampa, FL, USA), the vertebral axial decompression system (VAX-D) (Vat-Tech, Inc., Palm Harbor, FL, USA), SpineMED (CERT Health Sciences, LLC, Baltimore, MD, USA), and the Accu-Spina System (North American Medical Corporation, Aventura, FL, USA). Although some randomized trials of spinal compression therapy have suggested that symptoms of chronic LBP with or without sciatic pain might be relieved by intermittent axial traction methods using systems such as the DRX9000 and VAX-D²⁷⁻³⁰, and these treatments continue to be used in practice, there is a paucity of evidence in published data to support the efficacy of vertebral axial decompression treatment in individuals with discogenic LBP³¹.

Spinal mobilization and manipulation have recently received growing acceptance as effective treatments in the field of spinal care. Spinal mobilization is defined as the application of a series of manual force to the spinal segments which are within the patient's control to stop³². It often involves traction through the use of specially designed treatment tables, but spinal mobilization does not use high velocity and low-amplitude manual thrusts to the spinal joints³³. Flexion-distraction mobilization, an instrument-assisted procedure, is one of the most common forms of treatment for LBP and is used among physical therapists, chiropractors, osteopathic physicians, and medical physicians³⁴. The main goal of this technique is to open the posterior aspect of the functional spinal segment to allow greater sagittal diameter within the central and intervertebral canals^{35,36}. Thus, spinal mobilization or

manipulation can increase the range of motion of the spinal joint, and affect modulation of sensory input to the nervous system^{37,38}, the motor control system, and the pain processing system³⁹. Although a few studies have reported that spinal manipulation is effective in the treatment of discogenic LBP and sciatica^{40–43}, there are few randomized controlled studies which have evaluated the effectiveness of spinal mobilization in treatment of discogenic LBP.

Recently, there has been growing clinical use of therapeutic exercises that target the improvement of spinal and trunk stability. This type of exercise approach is known as lumbar stabilization exercise. Lumbar stabilization exercises are often used to protect affected lumbar spine structures from further injury, recurrent pain episodes, and degenerative change, as well as reduce the intensity of the pain and disability in LBP^{44–48}. There is strong evidence that lumbar stabilization exercises are likely to be beneficial for pain and function in patients with recurrent and chronic LBP^{49,50}.

Although LBP with or without sciatica is the most frequently reported type of pain by adults in industrialized countries, its management varies widely and the efficacy of many interventions for LBP secondary to herniated nucleus pulposus (HNP) remains elusive⁵¹. No studies to date in the clinical literature have specifically examined the effects of the combination of spinal decompression therapy via motorized axial decompression device and spinal mobilization as well as lumbar stabilization exercises on the treatment of discogenic LBP. Therefore, the purpose of this study was to determine the effects of spinal decompression therapy using DRX3000 combined with spinal mobilization and lumbar stabilization exercises on the treatment of patients with discogenic LBP.

SUBJECTS AND METHODS

A total of 30 adults with discogenic LBP (mean age, 34.06 ± 6.41 years; age range, 23–48 years; 14 males, 16 females) volunteered to participate in this study. To be included in this study the subjects were required to meet the following criteria: 1) participants were more than 18 years of age with discogenic LBP; 2) participants had to have one of the following diagnoses: herniated disc, bulging or protruding intervertebral discs confirmed by

magnetic resonance imaging (MRI) or computed tomography (CT), conventional radiograph of the lumbar spine, and clinical examination; 3) participants must have had imaging evidence of herniated disc or bulging or protruding intervertebral discs at a motion segment unit consistent with their current symptoms, since oftentimes structural imaging of herniated disc of MRI and/or CT and symptoms are poorly matched^{52–54}; and 4) all participants must have reported limited activities of daily living due to LBP that had an average score greater than 30/100 on the Korean version of the Oswestry Disability Index (ODI) which is considered to be a moderate disability^{55,56}.

Subjects using prescription of anticoagulants, corticosteroids, or opiate-based pain medication were excluded from the study, as were those with any of the following conditions: a history of lumbar spine surgery, pregnancy, severe osteoporosis, unstable spondylolisthesis, recent lumbar vertebral compression fracture below L1, local spinal osteomyelitis, meningitis, aortic aneurysm, primary malignant or metastatic spinal neoplasm, pelvic/abdominal malignancy, local bilateral pars defects, severe peripheral neuropathy, hemiplegia, paraplegia, cognitive dysfunction, cauda equina syndrome and disc pathology with sequestration. Subjects were also excluded if they were currently receiving workers' compensation.

Participants were recruited at a regional spine care center where the current study was performed. Participants were screened to check for inclusion/exclusion criteria. Any questions regarding this study were addressed. All participants signed an informed consent form approved by the local University Institutional Review Board prior to participation. Participant characteristics, primary diagnosis and MRI findings of participants are summarized in Tables 1 and 2.

The DRX 3000 spinal decompression system consists of a split table that is used to reduce friction on the lumbar muscles and a computer programmed to provide cycling distractive forces along the axis of the lumbar spine. The DRX3000 device has built-in air bladders and disc angle pull adjustments so that the intensity of intermittent distraction force is increased gradually to avoid muscle contractions in reaction to being stretched in the later part of spinal decompression. With proper pull angle settings to target the affected lumbar segment,

Table 1. Participants' characteristics

Characteristics	Values
Age (years)	34.06 ± 6.41
Sex (male/female)	14/16
Height (cm)	165.90 ± 7.89
Weight (kg)	62.90 ± 12.16
Side involved: left/right (%)	36/64
Location of pain	%
Pain in back/buttocks only	27
Pain below buttocks, above knee	33
Pain below knee	40
Duration of symptoms (months)	%
Less than 2	100
Previous history of LBP (% yes)	0

Note: Values are means ± SD (standard deviations); N = 30; LBP: Low Back Pain.

Table 2. Primary diagnosis and MRI findings of participants

Category	Values (%)
Primary diagnosis	
Herniated disc	43
Herniated disc and degenerative disc	57
Disc involved confirmed with MRI	
L4-L5	77
L5-S1	23
Changes in disc confirmed with MRI	
Protrusion and disc space narrowing	100

Note: MRI: magnetic resonance imaging.

traction can be applied to an isolated spinal disc slowly and cycle between brief moments of tension and relaxation (oscillation) delivered by a motor pulley.

The clinician attached a chest and shoulder harness to the upper body and then positioned the participant lying supine on the DRX3000 table with the hips and knees flexed and the lower legs supported on a stool. The pull angle setting was 15 degrees for the L4-L5 level and 10 degrees for the L5-S1 level. The initial weight setting was 25% of participant's body weight. The pulling weight was increased by 1.02 kg per session as tolerated and the final pulling weight was 50% body weight plus 4.54 kg to 9.07 kg. The distraction and relaxation times were set to 60 seconds and 30 seconds, respectively, and half of the pulling force during the distraction period was maintained during the relaxation period. Each participant was scheduled

for treatment 6 days per week for the first two weeks, and four times per week for two additional weeks. The total number of visits were 20 times over a period of 4 weeks and treatment was delivered for 30 minutes in each session. Fifteen minutes of superficial heating (hot pack) were provided followed by 5 minutes of ultrasound treatment (SM-250, Samson Med, Seoul, Korea) using a frequency of 1 MHz with a 5-cm² sound head at an intensity of 1.5 W/cm² in continuous mode, and 15 minutes of interferential current treatment (SM-850P, Samson Med, Seoul, Korea) at an intensity of approximately 25 mA prior to DRX3000.

All participants also received flexion-distraction mobilization which was performed by the use of a specially designed treatment table (MF 90, Wellness System, Seoul, Korea) with a moveable headpiece, a stationary thoraco-lumbar piece, and a moveable lower extremity segment which allows a clinician to manually move the patient through passive spinal flexion and extension. The clinician placed the participant prone on the treatment table, and then attached the ankles to the treatment table using the cuffs that provide distractive force. The clinician standing to the participant's side placed one hand over the lumbar region at the level of interest for stabilization, applying counter-traction forces, while the other hand controlled the caudal section of the table through the desired range of motion. Treatment was delivered for 5 minutes, 6 days per week for the first two weeks, and four times per week for two additional weeks so that the entire treatment consisted of 20 visits over a 4 week period.

Lumbar stabilization exercises using a sling device (Redcord, Staubo, Norway) in order to improve the dynamic stability of the lumbar spine through retraining the co-contraction pattern of the deep trunk muscles and abdominal muscles were also carried out. During treatment, each movement pattern was precisely guided by the clinician and once successful coordination of the action of the deep trunk muscles and abdominal muscles was achieved, more demanding tasks which require the large prime movers of the trunk were gradually integrated into the program. Each participant was treated 6 days per week for the first two weeks, and four times per week for two more weeks. The entire lumbar stabilization exercise program consisted of 20 visits over a 4-week course.

Table 3. Overall mean (\pm SD), mean differences (\pm SD) from pre-intervention

Measure	PI	10 sessions after TI	Discharge
ODI score*	35.40 \pm 9.60 ^{†‡}	23.18 \pm 12.18 ^{†¶}	18.07 \pm 12.02 ^{†¶}
ODI score difference from PI		-12.12 \pm 1.03	-17.33 \pm 1.00
SLR test (degree)*	35.23 \pm 9.01 ^{†‡}	57.53 \pm 20.97 [†]	64.30 \pm 19.40 [‡]
SLR test difference from PI (degree)		22.3 \pm 2.55	29.07 \pm 2.29

*Significant main effect for time ($p < 0.01$). [†]Significant difference between pre-intervention and 10 sessions after TI ($p < 0.01$). [‡]Significant difference between pre-intervention and discharge ($p < 0.01$). [¶]Significant difference between 10 sessions after TI and discharge ($p < 0.01$).

Note. Values are means \pm SD (standard deviations). ODI score range: 0 (none disability) to 50 (severe disability). ODI: Oswestry Disability Index; SLR: straight leg raise; PI: pre-intervention; TI: treatment initiation.

Outcome measures included straight leg raise (SLR) test of the affected side and ODI. For the SLR test, with the participant lying supine, the leg was passively raised by the clinician to the end range while the knee was maintained in extension. Measurement was conducted on the tibial crest, distal to the tibial tuberosity using an inclinometer. It has been shown that this test has good interrater reliability (intraclass correlation coefficient, 0.87–0.96)⁵⁷. Reduced ability to manage in everyday life due to LBP was estimated by using the 60-point ODI (0 being no overall pain and 50 being most severe back pain total score)^{55–57}. The ODI score was determined by the participant who checked 10 items with scores ranging from 0 (no back pain during activity) to 5 (severe pain during activity). ODI has a test-retest reliability coefficient of 0.92⁵⁸ and a validity of 0.62⁵⁸.

A one-way repeated analysis of variance (ANOVA) was used to determine whether there were any significant differences in outcome measures. Single degree of freedom mean contrasts were used to determine the source of any significant effects ($p < 0.05$)⁵⁹. The independent variable was time (pre-intervention, 10 sessions after initiation of treatment, and discharge, respectively). The dependent variables included SLR degree and ODI scores. The software package SPSS 14.0 KO (SPSS, Chicago, IL, USA) was used for statistical analyses.

RESULTS

All recruited subjects completed 20 treatment

sessions of traction combined with motorized flexion-distraction mobilization and lumbar stabilization exercises. All subjects who participated in the study were included in the data analysis. Subjects reported their current symptoms of LBP for less than 2 months prior to the intervention and no adverse events were noted during the course of the study.

Comparisons of changes in the ODI scores and SLR test at pre-intervention, 10 sessions after initiation of treatment, and at discharge (within 3 days of the last visit) were analyzed for participants with discogenic LBP. There was a significant main effect of time for the ODI score ($F(2, 28) = 175.44$, $p < 0.01$). Significant improvements were noted for the ODI scores at 10 sessions after initiation of treatment and at discharge as compared with the pre-intervention score ($p < 0.01$). The mean ODI score at 10 sessions after initiation of treatment and at discharge were 35 % and 49 % lower than the mean pre-intervention score ($p < 0.01$ respectively; Table 3). A significant improvement was also noted for the mean ODI score at discharge as compared with the mean score at 10 sessions after initiation of treatment ($p < 0.05$). The mean ODI score at discharge was 22 % lower than that at 10 sessions after initiation of treatment ($p < 0.01$; Table 3). There was also a significant main effect of time in the SLR test ($F(2, 28) = 136.27$, $p < 0.01$). The mean SLR value at 10 sessions after initiation of treatment and at discharge were 163 % and 183 % of the mean pre-intervention value ($p < 0.01$, Table 3). The mean measure at discharge was also 112 % of the mean at 10 sessions after initiation of

treatment ($p < 0.01$). Table 3 presents details of the outcome measures of ODI and SLR.

DISCUSSION

This study provides useful information as to how patients with discogenic LBP responded to 4 weeks of spinal decompression treatment combined with motorized flexion-distraction mobilization and lumbar stabilization exercises. Generally, participants in this study demonstrated significant improvements in ODI and SLR after 10 and 20 sessions of spinal decompression treatment via DRX3000 apparatus combined with spinal mobilization and lumbar stabilization exercises. These results are consistent with findings of previous studies^{29,60,61}, which reported visual analog scale and/or a disability scale improvements for patients with discogenic LBP after treatment with spinal decompression therapy combined with other treatment protocols such as heat, cold, and/or muscle stimulation.

The most common source of chronic LBP and nerve root entrapment syndromes most likely arises from damage to intervertebral discs⁶², and discogenic pain may be due to progressive annular fibrosis breakdown and tearing leading to posterior herniation of the nuclear pulposus causing pain, or damage to the internal disc structure⁶³. Previous studies^{64,65} have demonstrated that spinal decompression decreases intradiscal pressure which, in turn, may allow herniated discs to be reoxygenated, rehydrated and renutriented, facilitating disc metabolism and restoration.

In our current study patients with discogenic LBP received a prescription of a lumbar stabilization exercise program for 4 weeks that addressed impairments of abdominal and lumbar trunk musculature. Improvements in ODI and SLR were observed after application of this treatment along with other treatment programs. This may be due to the resultant enhanced activities of abdominal and lumbar trunk musculature. Previous studies⁶⁶⁻⁷² have demonstrated that in patients with LBP there is a disruption of the structure and function of the deep trunk muscles such as the transverse abdominis (TrA) and lumbar multifidus (LM). TrA and LM contractions normally occur in an anticipatory manner prior to limb movement in healthy adults, whereas contraction of TrA and LM is delayed or attenuated in patients with LBP^{67,73-77}. In addition,

fatty infiltration and atrophy of Type I and II muscle fibers occur in the LM of persons with LBP^{70-72,78-80}. It has been reported that lumbar stabilization exercise programs can normalize the functional and morphological changes in patients with LBP through improving the strength, endurance, and/or motor control of the abdominal and lumbar trunk musculature⁸¹⁻⁸⁶.

In this study, patients with discogenic LBP received flexion-distraction mobilization over a 4-week period that addressed the symptoms of LBP with associated lower extremity pain arising from lumbar disc herniation. Improvements in ODI and SLR were also noted with application of the treatment using flexion-distraction mobilization combined with other treatment protocols such as motorized traction and lumbar stabilization exercises. There are several possible explanations for the mechanical, physiologic, and anatomical effects of flexion-distraction mobilization procedures on the herniated intervertebral disc. It has been shown that flexion increases the central canal diameter and the intervertebral canal in the lumbar spine⁸⁷, as well as the size of the intervertebral foramen, up to 31% in the cervical spine⁸⁸. Flexion-distraction manipulation has also been demonstrated to increase the central canal diameter in the cervical spine⁸⁹. Additionally, distraction combined with flexion temporarily increased the lumbar disc spaces and facet joints⁹⁰. Previous studies^{91,92} have reported that distraction treatment manipulation can reduce disc protrusion in the lumbar and/or cervical spine. There is also evidence that flexion distraction can increase intradiscal pressure^{90,91}, and reduce hypertonicity of multifidi muscles that are assumed to play an important role in the maintenance of dysfunction and pain associated with the disc⁹³.

There were several limitations to our study. We examined a relatively small sample of patients with discogenic LBP, therefore future studies need to examine a larger subject group for better representation of the general population. Subjects were not classified based on a variety of symptoms or radiological imaging such as MRI or CT. This study sample consisted of adults with ages ranging from their 20's to their 40's; thus, the study population may not be representative of older adults who may have different characteristics of discogenic LBP. In addition, no MRI or CT imaging was taken to evaluate the changes in the

herniated disc after the completion of 4 weeks of treatment.

In conclusion, spinal decompression treatment combined with motorized flexion-distraction mobilization and lumbar stabilization exercises for 4 weeks significantly improved the clinical outcome measure of ODI and SLR in patients with discogenic LBP. It is difficult to make a casual relationship between the intervention and outcomes of this study because there was no control group in this study, and improvements may have been due to placebo or spontaneous recovery. Therefore, it is necessary to conduct further investigations using randomized controlled trials using a large group of patient and MRI and/or CT imaging before and after the intervention to evaluate the changes in the herniated disc.

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