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EFFECT OF PROPRIOCEPTIF NEUROMUSCULAR FACILITATION AND LUMBAR STABILIZATION EXERCISES ON MUSCLE STRENGTH AND MUSCLE ENDURANCE IN PATIENTS WITH LUMBAR DISC HERNIA

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Abstract:
Background/Objective: This study investigates the effect of lumbar stabilization and proprioceptive neuromuscular facilitation (PNF) training on muscle strength and muscle endurance. **Methods:** Sixty-four participants between the ages of 15 and 69 years, graded "protrusion and bulging lumbar herniation" according to the Macnab Classification, were divided into four groups of 16: lumbar stabilization training (strength training, 5 days/week for 4 weeks); PNF training (5 days/week for 4 weeks); physical therapy (hot pack, TENS, ultrasound, 5 days/week for 4 weeks); and control (without any application). Sociodemographic features were recorded and muscle strength tested. Before and after exercise, a visual analog scale (VAS) and Oswestry Disability Index (ODI) were measured by a physical therapist. After 4 weeks, the evaluations were repeated. **Results:** There were significant increases in muscle strength and muscle endurance in the lumbar stabilization group, who also showed significant improvement in pain intensity at rest and during activity, and in ODI (p<0.05). Similar results were observed in the PNF group (p<0.05), although not to the same extent. Patients undergoing physical therapy showed significant differences only in pain intensity at rest, at activity, and in ODI (p<0.05). There were no significant differences in the control group. **Conclusion:** Undertaking an appropriate physiotherapy and rehabilitation program aiming to reduce waist circumference of patients with low muscle strength and low muscle endurance will help to increase muscle strength and endurance and reduce pain, and contribute toward the correction of functional disabilities.

Keywords: disc herniation, endurance, lumbar stabilization exercises, PNF, strength

1. Introduction

Lumbar disc herniation (LDH) is a clinical entity characterized by compression of the spinal nerve roots and resultant back and leg pain. Though uncommon, LDH has been reported as a cause of recurrent low back pain (1).

Although more than 100 risk factors have been identified for LDH, it is difficult to determine a specific etiology. The most important risk factors are intense sporting activity, heavy lifting, frequent rotation of the body, exposure to vibrations, age, tall stature, obesity, smoking, and psychological and genetic factors (2).

It has been shown that in LDH patients; the strength and endurance of the back and abdominal muscles are reduced, and this aspect has been reported as a major predisposing factor for low back pain (3). Hence, an exercise program as part of conservative treatment of low back pain and after surgery would be of potential benefit for patients. Twomey and Taylor (4) have shown that behavioral and cognitive principles combined with exercise programs can be effective in reducing disability in patients with chronic low back pain.

The severity of symptoms in disc herniation depends not only on the amount of herniated disc pressure but also on nervous irritability. To reduce the sensitivity of nerve fibers to pain, symptomatic initiatives that include drugs, physical therapy, and psychological methods can be successful (5). The primary purpose of physical therapy is control of pain and inflammation, and secondarily to improve symptoms such as stiffness in the joints and muscle spasms. Physical therapy also delivers psychological effects. Agents used in physical therapy are generally administered in a combined regimen (6). We undertook this study to investigate the effect of lumbar stabilization training and proprioceptive neuromuscular facilitation (PNF) training on muscle strength and muscle endurance.

2. Methods

Sixty-four participants between the ages of 15 and 69 (53.04±14.59) years, who were graded as "protrusion and bulging lumbar herniation" according to the Macnab Classification, were enrolled. The participants were divided into four groups of 16 participants: lumbar stabilization training, PNF training, physical therapy, and control (i.e., without any application). Participants in the lumbar stabilization group performed strength exercises for 45 minutes, 5 days per week for 4 weeks under the supervision of a physical therapist. Those in the PNF group performed 5 days per week for 4 weeks using pelvic patterns of PNF administered by a physical therapist. Participants in the physical therapy group underwent hot pack, transcutaneous electrical nerve stimulation (TENS), and ultrasound therapy 5 days per week for 4 weeks. Complete neurologic and musculoskeletal examinations were performed in each group. Subjects with acute radicular signs or symptoms and those who had radiographic evidence of inflammatory disease affecting the spine, tumor, fracture, spondylolysis, spondylolisthesis, or scoliosis were excluded from the study.

After recording the subject's age, height, and weight, the body mass index (BMI) was calculated. The Oswestry Disability Questionnare (7) was used to assess pain. The maximum score in this questionnaire is 50, which represents 100% disability. A standard visual analog scale (VAS) was also used to assess pain. The patients graded their low back pain on a 10-point scale, anchored with the descriptors "no pain" at one end and "pain as bad as it could possibly be" at the other. Maximum pain severity was assessed by a blind-testing physician using the standard VAS (8).

Trunk muscle strength of all subjects was measured using a computerized isokinetic dynamometer (Cybex 770 Norm; Lumex, Ronkonkoma, NY, USA). Isokinetic studies were performed at Cybex 770 Norm 60°/sec, 90°/sec, and 120°/sec velocities before and after treatment. All measurements were made with the subject standing and stabilized at the knees, lower back, and chest, with the dynamometric axis positioned at the third lumbar vertebral body. For each subject, trunk flexion and extension contractions with maximal effort were performed with five repetitions at each velocity. Between each test repetition, the subjects rested for 20 seconds. Muscle strength was expressed using the peak torque (PT) given in foot pounds (ft lb): PT 60 (PT value at 60°/sec), PT 90 (PT value at 90°/sec), and PT 120 (PT value at 120°/sec) were used for evaluation.

Trunk muscle endurance of all subjects was measured using curl-up and dynamic back extension tests. Participants' abdominal muscle endurance (curl-up) was tested in the supine position. Lower limbs were in abduction and knees in semiflexion. Participants were asked to stand up and touch the knees with their hands using body flexion. In this position, the number of trunk flexions completed in 1 min by the participants was recorded (9). Participants' dynamic back extension endurance was tested in the prone position. Knees were in extension. Participants raised their heads and shoulders to the sternal notch level. In this position, the number of trunk extensions completed in 1 minute was recorded (10).

2.1 Treatment protocol

A. Lumbar stabilization exercises

Exercises were made in supine, prone, and standing positions. During each exercise, an abdominal corset was provided to enable isometric contraction of all muscles of the abdominal wall without any change in the position of the trained muscles (11).

B. PNF techniques (pelvis patterns)

Pelvic patterns can be performed in a side-lying, crawling, sitting, or standing positions. The side-lying position is ideal because it allows the pelvis to move freely and provides power dissipation for trunk motions (12).

C. Physiotherapy

Hotpack, TENS, and ultrasound therapy were applied to each participant.

Role of funding source: Non applicable

2.2 Data analysis

The results were analyzed using the Statistical Package for Social Sciences (SPSS) Version 17.0 for Windows (SPSS, Chicago, IL, USA). Descriptive statistical methods were used to evaluate sociodemographic characteristics. A p value of less than 0.05 was considered statistically significant. The Wilcoxon test was used to compare the treatment of intra-group parameters before and after treatment. The Kruskal-Wallis test was used to compare parameters between multiple groups. The Mann-Whitney U test was used for comparison of two groups of inter-related parameters. Within-group relationships of measurement parameters were evaluated by Spearman correlation analysis.

3. Results

The groups showed no difference in demographic and clinical characteristics (Table 1; p>0.05).

Table 1: Demographic characteristics of the groups

	Stabilization mean±SD	PNF mean±SD	PT mean±SD	Control mean±SD	Kruskal-Wallis	*p*
Age (years)	52.75±12.49	56.81±12.31	57.12±15.33	46.12±15.33	7.984	0.052
Height (cm)	170.37±9.30	166.25±12.39	168.18±11.09	169.43±10.11	0.620	0.891
Weight (kg)	76.12±10.32	75.81±9.28	79.06±12.85	76.31±10.87	0.827	0.827
BMI (kg/cm^2)	26.21±2.92	27.58±4.15	27.92±3.22	26.68±4.01	2.007	0.570

BMI = body mass index; PNF = proprioceptive neuromuscular facilitation; PT = physical therapy; SD = standard deviation.

When groups' evaluations before and after treatment were compared, statistically significant differences were found in VAS after treatment (at rest), VAS (at activity), Oswestry Disability Index (ODI), abdominal strength, endurance of back extensor, left hip flexion flexibility, sit and reach flexibility, 60°/sec trunk flexion, 90°/sec trunk extension, 90°/sec trunk flexion, 120°/sec trunk flexion, and 120°/sec trunk extension (Table 2).

Table 2: Comparison of internal evaluation results of all groups before and after treatment

		Stabilization		PNF		Physical therapy		Control	
		Mean±SD	Mean difference	Mean±SD	Mean difference	Mean±SD	Mean difference	Mean±SD	Mean difference
VAS (at rest)	BT	4.18±2.42	3.00	4.43±2.25	2.37	3.75±2.84	1.44	5.50±2.82	0.13
	AT	1.18± 1.47		2.06±1.65		2.31±1.62		5.37±2.44	
	p	**0.001***		**0.001***		**0.007***		0.527	
VAS (in activity)	BT	6.12±2.44	4.56	7.00±2.12	5.00	6.50±3.26	2.07	6.56±1.96	0.19
	AT	1.56±1.45		2.00±0.89		4.43±2.58		6.75±1.34	
	p	**0.003***		**0.002***		**0.001***		0.448	
Oswestry	BT	15.30±6.22	4.24	20.00±3.47	4.55	18.22±3.57	2.36	17.28±3.83	0.34
	AT	11.06±4.78		15.45±3.99		15.86±3.36		17.62±3.76	
	p	**0.002***		**0.001***		**0.002***		0.070	
Abdominal endurance	BT	27.50±5.91	4.87	26.87±5.58	4.88	28.31±6.85	1.44	24.12±5.47	2.50
	AT	32.37±6.55		31.75±6.30		29.75±6.88		24.62±5.23	

	p	**0.001***		**0.003***		0.063		0.108	
Back extension endurance	BT	27.43±4.51	5.00	25.75±6.67	10.12	27.06±7.92	1.12	25.37±2.96	0.31
	AT	32.43±6.45		35.87±8.07		28.18±7.81		25.06±3.02	
	p	**0.003***		**0.001***		0.065		0.058	
60°/s trunk extensors	BT	**46.12±43.99**	15.06	34.06±23.58	7.31	55.56±31.40	0.94	35.31±7.43	0.69
	AT	**61.18±41.65**		41.37±25.59		56.50±31.01		36.00±7.33	
	p	**0.003***		0.002*		0.458		0.204	
60°/s trunk flexors	BT	**71.18±68.45**	36.19	54.93±68.81	29.75	75.18±50.84	4.69	40.56±21.34	4.78
	AT	**107.37±56.84**		84.68±60.70		79.87±44.43		45.31±15.08	
	p	**0.013**		**0.002***		0.573		0.654	
90°/s trunk extensors	BT	**46.81±32.96**	5.19	26.75±10.58	4.87	34.68±11.94	2.31	29.87±10.27	0.006
	AT	**52.00±33.69**		31.62±11.57		32.37±14.66		29.81±11.42	
	p	**0.021**		0.063		0.037		0.646	
90°/s trunk flexors	BT	**43.00±33.57**	38.36	36.37±22.98	12.13	52.25±27.29	4.12	32.12±4.27	0.56
	AT	**81.68±53.43**		48.50±20.01		56.37±28.70		32.68±3.73	
	p	**0.000***		**0.002***		0.361		0.220	
120°/s trunk extensors	BT	**35.87±18.25**	3.44	33.50±16.70	5.18	37.87±16.02	0.81	24.68±5.36	0.07
	AT	**39.31±20.54**		38.68±12.62		38.68±15.47		24.75±5.73	
	p	**0.233**		0.015		0.213		0.781	
120°/s trunk flexors	BT	**35.62±17.08**	26.13	46.75±37.90	12.37	37.50±20.17	3.13	34.37±7.25	0.06
	AT	**61.75±31.96**		59.12±33.89		34.37±19.58		34.31±7.73	
	p	**0.003***		**0.001***		0.542		0.725	

AT = after treatment; BT = before treatment; VAS = visual analog scale.
*$p<0.05$

When pairwise comparisons of groups were conducted, there were significant differences in the stabilization group's ODI, left hip flexion flexibility, sit and reach flexibility, 90°/sec trunk extension, and 90°/sec trunk flexion muscle strength values when compared with values in the PNF group (Table 3).

Table 3: Comparison of evaluation results before and after treatment

		Stabilization Mean±SD	PNF Mean±SD	Physical therapy Mean±SD	Control Mean±SD	χ^2	*p*
VAS (at rest)	BT	4.18±2.42	4.43±2.25	3.75±2.84	5.50±2.82	3.925	0.269
	AT	1.18± 1.47	2.06±1.65	2.31±1.62	5.37±2.44	**24.444***	**0.001***
VAS (ın activity)	BT	6.12±12.44	7.00±2.12	6.50±3.26	6.56±1.96	1.460	0.691
	AT	1.56±1.45	2.00±0.89	4.43±2.58	6.75±1.34	**31.168***	**0.003***
Oswestry	BT	15.30±6.22	20.00±3.47	18.22±3.57	17.28±3.83	6.892	0.075
	AT	11.06±4.78	15.45±3.99	15.86±3.36	17.62±3.76	**21.305***	**0.002***
Abdominal endurance	BT	27.50±5.91	26.87±5.58	28.31±6.85	24.12±5.47	4.214	0.239
	AT	32.37±6.55	31.75±6.30	29.75±6.88	28.31±6.85	**20.048***	**0.001***
Back extension endurance	BT	27.43±4.51	25.75±6.67	27.06±7.92	25.37±2.96	3.161	0.367
	AT	32.43±6.45	35.87±8.07	28.18±7.81	25.06±3.02	**28.840***	**0.003***
60°/s trunk extensors	BT	46.12±43.99	34.06±23.58	55.56±31.40	35.31±7.43	7.635	0.054
	AT	61.18±41.65	41.37±25.59	56.50±31.01	36.00±7.33	7.214	0.065
60°/s trunk flexors	BT	71.18±68.45	54.93±68.81	75.18±50.84	40.56±21.34	4.452	0.217
	AT	107.37±56.84	84.68±60.70	79.87±44.43	45.31±15.08	10.614	**0.014***
90°/s trunk extensors	BT	46.81±32.96	26.75±10.58	34.68±11.94	29.87±10.27	7.459	0.058
	AT	52.00±33.69	31.62±11.57	32.37±14.66	29.81±11.42	**24.386***	**0.002***
90°/s trunk flexors	BT	43.00±33.57	36.37±22.98	52.25±27.29	32.12±4.27	7.219	0.065
	AT	81.68±53.43	48.50±20.01	56.37±28.70	32.68±3.73	**15.313***	**0.001***
120°/s trunk extensors	BT	35.87±18.25	33.50±16.70	37.87±16.02	24.68±5.36	5.671	0.128
	AT	39.31±20.54	38.68±12.62	38.68±15.47	24.75±5.73	11.257	**0.010***
120°/s trunk flexors	BT	35.62±17.08	46.75±37.90	37.50±20.17	34.37±7.25	0.195	0.978
	AT	61.75±31.96	59.12±33.89	34.37±19.58	34.31±7.73	11.707	**0.008***

AT = after treatment; BT = before treatment; VAS = visual analog scale.
*$p<0.05$

3.1 Discussion

Musculoskeletal system diseases have a negative impact on the quality of life of individuals and the nation's economy. Approximately 80% of individuals in a society are likely to experience low back pain at some period in their lives (13).

Although there are many reasons for low back pain, LDH is a major cause. In the treatment of LDH, different approaches involving surgery and physiotherapy are utilized. Many studies have reported reduced symptoms in a significant number of cases through non-surgical methods (14).

The main purpose of the various treatment modalities used in LDH therapy is to reduce pain, inflammation, muscular symptoms, and joint stiffness. In non-controlled studies, the efficacy of these modalities has been demonstrated in the treatment of low back pain (15).

When the physical properties of participants enrolled in this study were examined, there was no statistically significant difference in age, height, weight, and BMI, consistent with previous findings in the literature (16).

With regard to muscle strength, muscle endurance, and flexibility, when individuals with back pain are compared with unaffected counterparts as determined by numerous test protocols, they show low functional performance and physical fitness (17). Low physical fitness of the muscles that support the spine (insufficient strength, endurance, flexibility, and body composition) is a significant risk factor for low back pain (10).

The aim of therapeutic exercises is to improve muscle strength, endurance, and flexibility. Reduced muscle strength, endurance, and flexibility cause limitations in functional activity (18). A major finding of our study is the notable improvement in muscle strength, endurance, and flexibility after stabilization and PNF exercise programs. The assessments made in the lumbar region before the start of the treatment program show markedly lower muscle strength in both groups. At the end of the treatment program, there was a statistically significant increase in muscle strength in the lumbar region in the stabilization and PNF groups in comparison with physical therapy and control participants.

A sizeable number of individuals who have LDH also have chronic back pain. Long-term low back pain restricts the activity causes muscle atrophy. It has been shown that atrophy occurs in the lumbar region of the muscle in LDH patients (19).

Atrophy results in extremely weak and easily fatigued muscles. Tired back muscles with lower endurance lead to an increase in bending stress on the ligaments and intervertebral discs. In addition to causing pain and inactivity, this can also cause reflex muscle inhibition, leading to further attenuation of back muscles and atrophy (20). The provision of muscle strength and endurance around the spine is considered to play an important role when exercise is planned and performed to achieve spinal stability (21). When the results of our study are interpreted from this point of view, it can be confidently stated that a lumbar stabilization exercise program applied for 4 weeks in the clinic is effective in significantly enhancing lumbar muscle strength and endurance.

In 2014, Kwang et al. (22) compared 15 obese patients with chronic low back pain with 15 control individuals. The exercise program for the experimental group consisted of the scapular depression pattern of anterior-posterior pelvic elevation and the elevation pattern of the application of anterior-posterior depression. The control group undertook back-strengthening exercises. As a result, significant progress and significant improvements were observed in the experimental group's flexibility of lumbar flexion and extension, as well as ODI. Significant improvements in pain were also observed. The difference between our study and this one is that we used pelvis patterns applied to patients with LDH, which to our knowledge has not previously been reported.

Regarding pain and disability, most studies report that exercise is an effective method to treat chronic low back pain (23). These data are in agreement with our present results, wherein significant improvements were observed in pain intensity at rest and activity, and in ODI values, in both the stabilization and PNF groups.

Franca et al. (24) conducted a study comparing the effects of exercises to strengthen abdominal and trunk muscles and lumbar stabilization exercises on pain, functional disability, and transverse abdominal muscle activation. The study included 30 patients randomly divided into two groups. Patients were evaluated according to pain (VAS and McGill pain questionnaire), functional disability (Oswestry Inability Survey), and transverse abdominal muscle activation capacity (pressure biofeedback device), and exercised for 30 min twice per week for 6 weeks. Pain reduction and functional recovery from baseline in both groups significantly increased ($p<0.001$). In the lumbar stabilization group, significant improvements were found in comparison with the strengthening group ($p<0.001$). In the lumbar stabilization exercise group there was a significant increase in transverse abdominal muscle activation when compared with the strengthening group. These results are consistent with those of the present study.

Tuğcu et al. (25) studied 37 patients with chronic mechanical low back pain. They separated patients into two groups, applying exercise therapy to one group and hot pack, TENS, and ultrasound to the other. In the early stages, they found in both groups a statistically significant decrease in functional disability and patients' pain sensation. Similar to the results of our current study, in the hot pack/TENS/ultrasound group a statistically significant reduction was found in the pain and disability values.

Grubisic et al. conducted a study of 31 patients with chronic mechanical low back pain, separated into a treatment group and a placebo group, to evaluate the efficacy of ultrasound. As medication, only paracetamol was given to patients. No statistically significant difference was found between the treatment and placebo groups. Therapeutic ultrasound was effective in reducing the pain during treatment, but no functional recovery was seen in chronic low back pain. In the present study, there was a significant reduction in pain levels of patients upon application of ultrasound. In addition, distinct from the Grubisic et al. study, hot pack and TENS were applied alongside ultrasound therapy, resulting in significant improvement in patients' disability (26).

The efficacy of TENS for acute pain is controversial. In randomized controlled studies, positive short-term effects on chronic pain were apparent using TENS. It is proposed that the effect of TENS is created by a gate-control mechanism. In studies of hot and cold applications, application of heat was reported to be effective in reducing pain in patients with acute or subacute low back pain (27). In our study, we also found a statistically significant decrease in pain levels when such physical therapy modalities were applied.

We consider the small number of patients in the groups and the short follow-up time to be the main limitations of our study. A larger population with a longer follow-up period should increase the statistical power. The lack of isometric muscle strength measurements is another limitation. We did not use this as an evaluation criterion because in their study, Renkawitz et al. (28) showed that isometric muscle strength had no influence on patients with low back pain. In addition, in future studies the long-term effects of treatment on quality of life and recurrence of low back pain in LDH patients should be investigated.

Lumbar stabilization exercises are more effective when compared with PNF exercises. These exercises have the advantage of being easily applicable and efficient. Therefore, these exercise programs seem superior in this context. However, it is possible that the effectiveness of both programs may depend on the fact that they were carried out in hospital conditions under supervision. Therefore, we believe that comparative studies in the future should include a group of exclusively home-exercise training programs. Such studies would assuredly help in determining exercise protocols for the treatment of low back pain in LDH.

3.2 Clinical messages

Lumbar stabilization exercises have more efficacy than PNF exercises in the treatment of individuals with lumbar disc hernia.

The standard lumbar stabilization exercises program proved to be easily performable and inexpensive, and is the preferred option for exercise when treating pain arising from LDH.

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