Comparison of Effects of Standard, Isokinetic and Unloading Exercises in the Treatment of Lumbar Spinal Stenosis

Lomber Spinal Stenoz Tedavisinde Standart, İzokinetik ve Yük Alma Egzersizlerin Etkinliklerinin Karşılaştırılması

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ABSTRACT

Objective: To investigate the effects of different exercise programs used for patients with lumbar spinal stenosis on pain, functional capacity, and lumbar flexor and extensor muscle strengths.

Methods: Diagnosed with lumbar spinal stenosis, 112 patients were included into the study. Patients were classified into three groups as standard, isokinetic and unloading and followed-up during pre-and post-treatment periods and 4th, 12th and 24th weeks. While evaluating patients, the parameters of Visual Analogue Scale, Oswestry Disability Index and Beck Depression Inventory were used. Total gait duration was defined as "second" at the rate of 1.2 kph, and lumbar muscle strength was measured via isokinetic device.

Results: A significant amelioration was observed, continuing until 4th-week follow-ups in Visual Analogue Scale and Oswestry Disability Index scores in each group. Amelioration related to total gait duration lasted until 24th week. In each group, an increase was determined in the measurements of lumbar muscle strength performed with isokinetic device.

Conclusion: As a result, an improvement was obtained in pain, disability, functional parameters and muscle strength in each group of lumbar spinal stenosis patients. Although unloading exercise group was determined to be with better outcomes, such a difference disappears in long term.

Keywords: Lumbar spinal stenosis, exercise, unloading exercise, isokinetic exercise

ÖZET

Amaç: Bu çalışmamızda lomber spinal stenoz (LSS)'li hastalarda kullanılan farklı egzersiz programlarının ağrı, fonksiyonel kapasite ve lomber fleksiyon ve ekstansiyon kas kuvvetleri üzerindeki etkilerini araştırmayı amaçladık.

Yöntemler: Çalışmaya LSS tanısı konulan 112 hasta alındı. Hastalar randomize olarak standart egzersiz, izokinetik egzersiz ve yük alma egzersiz grubu olarak üç gruba ayrıldı. Tedavi öncesi (TÖ), tedavi sonrası (TS), dördüncü, on ikinci ve yirmi dördüncü hafta takipleri yapıldı. Hastalar değerlendirirken, Vizüel Ağrı Skalası (VAS), Oswestry Disabilite İndeksi (ODİ) ve Beck Depresyon Envanteri (BDE) parametreleri kullanıldı. Toplam yürüme süresi (TYS); 1,2 km/saat hızında "sn" cinsinden belirlendi. Lomber kas güçleri izokinetik cihaz yardımıyla ölçüldü.

Bulgular: Her üç grupta da VAS ve ODİ değerlerinde 4. hafta kontrollerine kadar devam eden anlamlı iyileşme görüldü. TYS' deki iyileşme üç grupta da 24. haftaya kadar devam etmekteydi. İzokinetik cihaz ile değerlendirilen lomber kas gücü ölçümlerinde her üç grupta da artış görüldü.

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Received/Geliş Tarihi: 15.05.2012
Accepted/Kabul Tarihi: 27.11.2012

Presented in "2nd Medical Rehabilitation Congress" (04-07 November 2010, Ankara, Turkey)

Sonuçlar: Sonuç olarak LSS'li hastalarda üç egzersiz grubunda da ağrı, disabilite, fonksiyonel parametreler ve kas güçlerinde iyileşme sağlanmıştır. Yük alma egzersiz grubu diğer gruplardan daha üstün görülmekte ise de uzun dönemde bu fark ortadan kalkmaktadır.

Anahtar sözcükler: Lomber spinal stenoz, egzersiz, yük alma egzersizi, izokinetik egzersiz.

Introduction

Lumbar spinal stenosis (LSS) is the narrowing taking place in lumbar spinal canal, nerve root canal or intervertebral foramen due to different influences (1). One of the leading causes of disability, LSS is a frequently encountered condition, especially in the elderly (2). After the evaluation, patients should be informed on the treatment modalities of LSS, and novel treatment regimes should be prepared. The purpose in the management of LSS is to increase functions and to decrease pain severity by diminishing level of disability (1, 2).

LSS has two therapeutic options as conservative and operative (3, 4). In light of literature regarding LSS treatment, it will be seen that most of the studies are related to either observational conservative studies including exercises (4-8) or studies comparing the conservative treatment and surgery (9-12). In studies related to conservative treatment modalities including exercise, physical treatment, injection and massage, etc., a rate of improvement ranging from 15 to 43% has been reported during at least one-year follow-ups (4, 6, 7). However, in 2 to 4-year follow-ups of LSS patients with severe symptoms, surgery has been reported to be superior to conservative treatment (10, 12). However, such a difference is reported to disappear over 8 to 10-year follow-ups (11**)**.

Conservative treatment of LSS includes analgesics, NSAIDs, epidural steroid injections, physical treatment modalities, postural training of patients, spinal manipulation, orthesis and therapeutic exercises. Therapeutic exercises, however, involve stretching, strengthening, condition and postural training (13). While increasing in lumbar extension or weight-bearing posture, LSS symptoms ease in flexion posture and non-weight bearing posture (14, 15). Due to postural effects, aerobic exercises appropriate for the condition have been defined. One of such exercises is also the treadmill walking with body weight support (16, 17). The mechanism here is that vertical traction force provides an ease by decreasing axial compressive spinal loading (15, 16).

The present study was designed because no controlled studies investigating and comparing the effects of different exercise programs applied with physical treatment modalities in long follow-ups were present in literature. In our study, therefore, what effects various exercise programs had on pain, functional capacity and lumbar muscle strength was aimed at to be investigated in LSS cases.

Materials and Methods

After the application for scientific research project in February 2004, 112 LSS patients followed-up in the Department of Physical Medicine and Rehabilitation of Necmettin Erbakan University between April 2004 and April 2010 were included into the study.

Those with LSS symptoms, over 45, describing neurologic claudication and with at least one narrowing at one level in lumbar canal in lumbar magnetic resonance imaging (MRI) constituted the inclusion criteria in the study.

Those with unstable cardiovascular and pulmonary diseases, to inhibit walking and testing by isokinetic device, with polyneuropaties and muscle-skeleton system diseases to inhibit walking, without palpable peripheral pulses, and with the history of previous lumbar surgery were excluded from the study.

Detailed history was obtained from all participants, and ages, gender, history of lumbar traumas, duration of lumbar symptoms (as months) were recorded. Height and weight were calculated via body mass index (BMI) [weight (kg)/square of height (m^2)]. Systemic, locomotor system and neurologic examinations were performed. Whole blood count, brucella titration and biochemical blood tests were performed for all patients.

Patients were randomizingly classified into three groups as standard exercise group (group 1) (n:38), isokinetic exercise group (group 2) (n:37) and unloading exercise group (group 3) (n:37).

All patients were hospitalized and administered with paracetamol (1500 mg/day) and 15 sessions of physical treatment modalities without deep heating properties as a part of primary treatment regime (TENS for 20 min and hot pack application for 20 min in each session). All patients were advised to apply an exercise program including pelvic tilt, modified lumbar flexion, hamstring and stretching exercises to hip flexors and paraspinal muscles and to follow the exercise program at home after the discharge.

For patients in group 1, the program involved five sessions of exercise per week in the attendance of a physician, as total 15 sessions during the hospitalization. While no other treatment options were administered, patients in this group were recommended to follow the exercise program regularly for at least three days a week at home.

For those in group 2, an isokinetic exercise program along with primary treatment was administered for 20 min/day, 5 sessions a week, totally 15 sessions in the attendance of a physician. Isokinetic exercises were performed at the rates of 60°/sec, 120°/sec and 180°/sec and with body movements of 70º (ranging from flexion of 50º to extension of 20º). Each session was composed of 3 sets. Each set involved five repetitions of concentric-concentric movements at the rates of 60°/sec, 120°/sec and 180°/sec. There were 20-second intervals between each of five repetitions. Patients were advised to follow exercise programs at home at least for three days a week after the discharge.

For those in group 3, in addition to primary treatment, patients received five sessions of unloading exercises per week, total 15 sessions, in the attendance of a physician. In unloading exercise program, all patients were asked to walk with the help of an unloading exercise device by decreasing 45% of body weight in the first five sessions, and then 30% in the following sessions. Patients were made to walk on the treadmill at the rate of 1.2 km/hour for 20 min or until a pain in the form of NC was felt. Patients were advised to follow exercise programs at home at least for three days a week after the discharge.

Assessment Parameters

In order to determine the levels of pain in patients, Visual Analogue Scale (VAS) of 10 cm was used (18), and the patients were asked to mark the level of pain on the scale when feeling the pain at the movement. Oswestry Disability Index (ODI) was used to determine how effective the lower back pain was on patients' daily activities (19, 20). In the determination of depression, Beck Depression Inventory (BDI) was used (21).

To define total gait duration (TGD), patients were asked to walk on the treadmill at zero angle, without holding with the handle bars and with upper extremities free on both sides at a rate of 1.2 km/hour. Not patients were particularly requested to stand right. The duration from the initial of walking to the moment when the patient wished to quit walking due to NC was recorded as second and TGD.

Measurements of lumbar muscle strength were performed with Biodex Isokinetic Dynamometer (Sys 3 Pro USA). So as to control movements in other joints during the test, the stabilizers of knee, hip and chest were placed appropriately. Rotational axis of dynamometer was adjusted to the level of L5-S1. The extension and flexion of low back were concentric-concentric isokinetically tested. Isolated contractions of abdominal and erector spina muscles were obtained by decreasing the help of hip flexors to body movements while the hip was at 90º. The range of joint motion was adjusted as 70° (from flexion of 50° to extension of 20°). Under the criteria of test protocol, prior to recording and after patients were made to perform three repetitive lumbar flexions-extentions at the rates of 60°/sec and 120°/sec at submaximal strength for patients to adapt and get ready for the test, the main protocol was carried out. The patients were made to perform five repetitions first at 60°/sec, the low rate, and then at 120°/sec, higher rate. As assessment parameters, values of peak torques (PT) obtained from lumbar flexions and extentions at both angular rates were recorded as Newton-meter (Nm). The measurements of VAS, ODI, TGD and muscle strength were performed before and after the treatment (BT and AT), and during 4th, 12th and 24th-follow-ups. The measurements of BDI, however, was assessed BT, and during 12th and 24th-week follow-ups.

Statistical Analysis

Analysis was performed via SPSS 16.0 version package program. Mann-Whitney U test was used to compare two non-normally distributed numeric variables between groups. Student's t test was used to compare independent variables between groups. In the comparison of repetitively measured parameters, two-way variation analysis (ANOVA) was used (time and groups). In cases where scores of variation analysis test were significant, Bonferroni correction was performed as Post Hoc test in the comparison of groups ($\alpha = 0{,}005/3 = 0{,}008$). In order to define the different group, Student's t test was used with Bonferroni correction. Paired t test is used in the comparison of groups to define the time in Bonferroni corrected dependent groups. Significance rate was accepted as $p < 0.05$.

Results

In the evaluation BT, no significant difference was observed among groups in terms of age, BMI, mean duration of symptoms (month) and values of VAS and ODI ($p>0.05$) (Table 1).

In the assessment of VAS parameters obtained after the treatment and follow-up periods, a significant amelioration was observed in each group during AT and 4th-week follow-up, compared to initial VAS values. While the improvement was still significant in group 3 during 12th week, no significant difference was observed in each group at week 24, compared to values BT. In the comparison of groups, the improvement in group 3 was higher than in groups 1 and 2 for AT follow-ups, whereas it was more significant than only group 1 during 4th-week follow-ups (Table 2).

Upon the evaluation of ODI values, a significant and higher improvement was observed in each group at AT and 4th-week follow-ups, compared to initial ODI values.

Table 1. Demographic characteristics of patients between groups.

	Group 1 (n:30)	Group 2 (n:30)	Group 3 (n:30)	P
Age (year)	57.1±7.6	55.8±9.4	57.4±7.9	>0.05
BMI (kg/m²)	32.3±3.7	29.9±5.1	32.1±4.0	>0.05
Symptom Duration (Month)	48.2±2.2	44.4±26.7	46.1±23.8	>0.05
VAS	7.55±1.2	6.74±1.4	7.66±0.8	>0.05
ODI	31.3±8.0	31.8±8.2	32.6±5.1	>0.05
BDI	12.90±5.71	12.90±5.32	13,10±5,94	>0.05

BMI: Body mass index, VAS: Visual Analogue Scale, **ODI;** Oswestry disability index, **BDI;** Beck depression Inventory.

Table 2. Change in mean VAS, ODI and TWT measurements.

	Group 1 (n:30)	Group 2 (n:30)	Group 3 (n:30)
VAS			
BT	7.55±1.2	6.74±1.4	7.66±0.8
AT	5.62±1.8 [a]	5.25±1.7 [a]	4.26±1.3 [abc]
4Th Week	6.20±1.2 [a]	4.77±1.7 [a]	5.03±1.2 [ab]
12Th Week	6.44±1.3	5.51±2.0	5.73±1.5 [a]
24Th Week	6.82±1.2	5.74±1.5	6.36±1.4
ODI			
BT	31.3±8.0	31.8±8.2	32.6±5.1
AT	26.0±7.9 [a]	26.8±7.1 [a]	24.2±5.6 [abc]
4Th Week	27.8±7.5 [a]	26.3±7.1 [a]	25.2±6.1 [ac]
12Th Week	28.0±7.6	27.0±6.7 [a]	26.7±6.4 [a]
24Th Week	29.1±7.6	28.7±7.0	28.6±6.7 [a]
TWT			
BT	181.6±100.0	149.6±85.1	190.1±177.0
AT	265.4±155.9 [a]	200.8±127.0 [a]	315.9±172.0 [ac]
4Th Week	248.6±149.3 [a]	202.7±129.3 [a]	267.0±172.0 [ac]
12Th Week	257.33±135.7 [a]	205.1±156.3 [a]	258.0±203.5 [a]
24Th Week	234.0±135.9 [a]	198.8±159.0 [a]	232.1±190.0 [a]

BT: Before Treatment, **AT:** After Treatment, **VAS:** Visual Analogue Scale, **ODI;** Oswestry disability index , **BDI;** Beck depression Inventory, **TWT;** Total Walking Time, **a:** vs basal values; p<0.05 **b:** vs standart exercise group p<0.05 **c:** vs isokinetic exercise group p<0.05

The improvement rates observed at 12th-week follow-ups in group 2 and the one seen in group 3 at 12th and 24th-week follow-ups still kept on being significant. In the comparisons of groups, the improvement in group 3 was higher than group 1 and 2 at AT follow-ups, whereas it was more significant only than group 2 at 4th-week follow-ups (Table 2).

In the evaluation of TGD values, a significant improvement was observed at AT, 4th, 12th and 24th-week follow-ups, compared to initial TGD values in three groups. When groups were compared, the improvement was found to be more significant in group 3 than group 2 at AT and 4th-week follow-ups (Table 2).

In the evaluation of lumbar extension PT values obtained at the rates of 60°/sec and 120°/sec after the treatment and follow-up periods, a significant improvement was detected at AT and 4th-week follow-ups in three groups, compared to initial PT values. The improvement seen in group 3 still kept on being significant at 12th and 24th-week follow-ups, as well. In the comparison of groups, however, no significant difference was observed (Figure 1).

In the evaluation of lumbar flexion PT values defined at the rate of 60°/sec after the treatment and follow-up periods, a significant improvement was seen at AT and

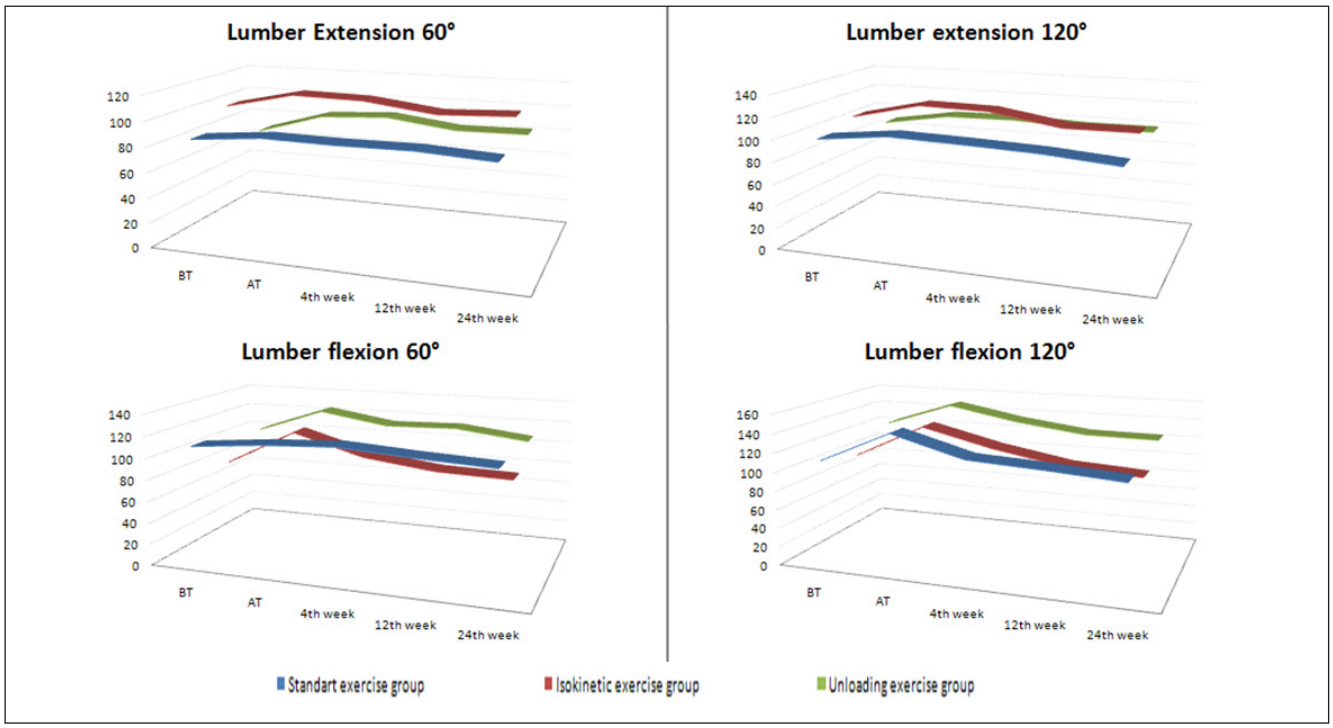

Figure 1. Lumbar flexion and extansion muscle measurements (peak torque).

4th-week follow-ups in three groups, compared to initial PT values. The improvement seen in group 2 and 3 still kept on being significant at 12th and 24th-week follow-ups. Among groups, however, no significant difference was observed (Figure 1).

In the evaluation of lumbar flexion PT values defined at the rate of 120°/sec after the treatment and follow-up periods, a significant improvement was seen at AT and 4th-week follow-ups in three groups, compared to initial PT values. The improvement seen in group 1 still kept on being significant at 12th-week follow-ups. Among groups, however, no significant difference was observed (Figure 1).

In the comparison among groups and the evaluation in each group as to BDI scores, no significant difference was observed.

Discussion

In the present study, the effects of standard, isokinetic and unloading exercise programs performed by patients with LSS were investigated on the parameters of VAS, ODI, TGD, BDI and lumbar muscle strength. All of three exercise programs provided marked improvements in pain, disability, functional parameters and muscle strength. However, when compared with other types of exercises, unloading exercise was significantly superior to others in terms of VAS, ODI and walking duration, but the difference disappeared at weeks 12 and 24.

In literature, two randomized controlled studies were encountered, investigating the effects of exercise on LSS. The first one is an exercise study comparing manuel treatment, lumbar flexion exercises and body-weight supported (BWS) treadmill ambulation program with lumbar flexion exercise, walking program on treadmill and subtherapeutic ultrasound treatment (22). In both groups in the study, a significant improvement was observed, but in the examination at 6th week, a better rate of significant improvement was detected in the group with BWS treadmill ambulation program, compared to the other group. However, in the assessments performed in 1st year, the difference disappeared.

The second study was composed of two groups: one with BWS treadmill exercise and the other including cycling exercise (23). In addition to these exercises, all patients received deep heating, lumbar traction and flexion exercises. Compared the measurements in both groups, no difference was reported, and it was suggested that BWS treadmill and cycling exercises may be of equal value in the conservative treatment of patients with LSS. It was also stated that accompanying physical therapy and natural course of the disease may influence the outcome positively (23). In this study, follow-ups were maintained only during the treatment period, but no long-term effects of the treatment were followed-up. The findings obtained in the two studies support that exercise programs provide a significant improvement clinically in LSS patients (22, 23).

Our study, different from those two studies in literature, is the first followed-up in the long run after the treatment. In studies performed prior to ours, controls were mostly performed at AT and 1st year. In our study, however, detailed controls were performed in a longer and more frequent way at AT, 4th, 12th and 24th-week follow-ups. A significant decrease was detected at the rate of pain after treatment in unloading exercise group in our study. The difference disappeared after 12th week. A significant decrease was found in all groups as to the parameter of disability at 4th week. The decrease continued up to 12th week in isokinetic exercise group and up to 24th week in unloading exercise group. As to decrease of pain and disability, unloading exercise group was of higher improvement rates, compared to other two groups. In duration of walking, a significant increase was present, continuing until 24th week in all groups.

One of the dynamic factors playing a role in the pathology of LSS is also axial loading (1). Lumbar traction is a beneficial modality to provide distraction of vertebrae, to widen intervertebral foramina, to decrease venous congestion and to increase axoplasmic flow (15,16). Therefore, unloading exercise involves using a traction harness and the application of a vertical traction force, while the patient ambulates on treadmill (15,16). So, the traction force is aimed to reduce gravitational force on spine (15,16). The procedure to reduce the compressive loading on spine during ambulation may be beneficial in treatment of LSS patients. In other words, clinical complaints might be reduced or disappear because axial loading was reduced by unloading. Hence, more practical and successful outcomes may be achieved via unloading exercise.

Among treatment modalities generally advised to LSS patients are strengthening, aerobic and flexion exercises, and tractions. Related studies encountered in literature are generally concerned with exercises programs on chronic back pain. In four randomized, well-designed and controlled studies related to chronic back pain, strengthening/reconditioning exercises were compared to the types of other exercises (conventional general physical treatment exercises, stretching exercises and aerobic exercises, etc.), but no statistically significant difference was obtained between strengthening exercises and other exercise groups (24-27). Likewise, exercises were seen to provide an effective improvement in pain and functional parameters in studies related to LSS. In other words, whatever the types of exercise are, a significant improvement is also obtained in the treatment of LSS patients, as with other studies related to chronic back pain.

In a study where isokinetic and standard exercise programs were compared, no significant difference was observed in terms of pain relief (28). Also, in another similar study, isokinetic and standard exercise programs were found to lead to similar effects. Standard exercise programs were reported to be preferable due to both simple and cost-effective (29). Objective measurement of lumbar muscle strength was obtained via an isokinetic dynamometer in our study. An increase forming in lumbar flexor and extensor muscle strength was demonstrated in all exercise groups.

As the limitations of the study, the following may be suggested: mean age rates of participants in the study ranged from 55 to 57 (younger population, compared to mean age rate of LSS patients), shorter duration of symptoms and inexistence of a blind researcher evaluating patients. In addition, unloading and isokinetic exercises given to participants are unlikely to be maintained out of hospital. Therefore, the patients were asked to perform only standard exercise programs at home. In addition, it was unlikely to indicate the rate of contributions of exercise programs given BT and maintained at home to the changes occurring in assessment parameters of patients during long term follow-ups.

Conclusion and Recommendations

In conclusion, a significant improvement was obtained in each group of LSS patients in terms of pain, disability, functional parameters and muscle strength. Unloading exercise group was observed to have better improvement rates, compared to other groups. However, such a difference was found to disappear at 12th and 24th weeks in such parameters as VAS, ODI and duration of walking. With such findings, it is seen that successful outcomes are achieved via exercise programs in LSS patients. Standard exercise is a simpler and more cost-effective program to be maintained at home. Therefore, standard exercise programs should certainly be recommended at home if other exercise programs are inapplicable. As a result, a regular exercise program added to physical treatment protocols is seen as a beneficial therapeutic option for LSS patients.

Acknowledgement

Authors thank Numan Duran for language editing.

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