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Multimodal Assessments of Effectiveness of Physical Therapy for Patients with Lumbar Spinal Stenosis

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Abstract

Background
It has been reported that preoperative depression status affects the postoperative outcome significantly in patients with lumbar spinal stenosis (LSS) treated with surgery. However, characteristics of patients with LSS that might respond to physical therapy are not known.

Objective
To evaluate which patients with LSS are responded to physical therapy using multimodal assessments of physical and psychological factors.

Methods
Patients presenting with bilateral symptoms of neurogenic claudication caused by central LSS were enrolled. Patients were treated with physical therapy once a week for 6 weeks. Clinical outcomes were measured using the Zurich Claudication Questionnaire (ZCQ); visual analog scale of low back pain, leg pain, and leg numbness; Japanese Orthopaedic Association Back Pain Evaluation Questionnaire; Pain Catastrophizing Scale; Pain Anxiety Symptoms Scale; Hospital Anxiety and Depression Scale; Self-Rating Questionnaire for Depression (SRQ-D); and Biodex isokinetic dynamometer at baseline and 6 weeks after intervention. According to Stucki's criteria for the satisfaction scores of the ZCQ subscales completed after intervention, patients were divided into the satisfied group (Group I) and the unsatisfied group (Group II). The characteristics of those patients with LSS who can obtain satisfactory results with our physical therapy programs were clarified.

Results
Groups I and II had 25 and 13 patients, respectively. There were no differences in the demographic data and MRI findings between the two groups. At baseline, however, there was a significant difference in the SRQ-D (Group I, 7.2± 4.1 points vs. Group II, 10.9± 2.9 points). Improvements in pain, and disability, and pain catastrophizing favored the Group I at 6 weeks after the interventions.

Conclusions
Depressive symptoms might interfere with an optimal short-term outcome possibly obtained by physical therapy in patients

with LSS. Our results suggest that assessments and treatment of depression are needed to improve the clinical outcomes of physical therapy for patients with LSS.

Keywords: Depression; Exercise; Lumbar spinal stenosis; Neurogenic intermittent claudication; Physical therapy

Introduction

Lumbar spinal stenosis (LSS) is defined as any narrowing of the lumbar spinal canal, nerve root canal, or intervertebral foramina [1]. It is usually caused by spinal degenerative conditions. Patients present one or a combination of several symptoms, such as low back pain, leg pain, leg numbness, and neurogenic claudication, which occur secondary to narrowing of the spinal canal, nerve root canal, or intervertebral foramina [2]. Symptoms are exacerbated by lumbar extension or weight-bearing postures, but are relieved with flexion or non-weight-bearing postures [3,4]. Patients with stable symptoms are treated generally with conservative treatments that may include epidural steroids, oral medication, and physical therapy. When patients fail to respond to conservative treatments, surgery is usually considered.

LSS has become an increasing cause of quality of life impairment in the elderly population [5,6]. In a cohort of Japanese patients with LSS, Matsudaira et al [7] demonstrated inferior physical and mental health-related quality of life at baseline. Sinikallio et al [8] reported that preoperative depression status affects the postoperative Oswestry disability index, Stucki severity scores, and visual analog pain scale significantly in patients with LSS treated with surgery 3 months postoperatively. These reports suggest that it is important clinically to evaluate mental or psychological impairments for patients with LSS. Therefore, multimodal assessments of patients with LSS before and after conservative and surgical treatments are necessary for spine care and may result in an improvement in clinical outcomes.

The Spine Patient Outcomes Research Trial (SPORT) showed evidence that symptomatic LSS patients treated surgically maintained a greater improvement in pain and function at the 4-year time point than did those receiving nonoperative care [9]. In this trial, the nonoperative care was not systematic or methodical. With regard to conservative treatments for patients with LSS, several researchers reported the efficacy of oral medication, such as limaprost alfadex [10], and physical therapy [11-15]. However, in reports regarding physical therapy, pain and walking distance were the only assessments for patients. It is still unknown which types of physical therapies and outcome measures are useful and who responds to physical therapy among patients with LSS. By clarifying which patients with LSS are responded to physical therapy using multimodal assessments, it might be possible to decrease the patients undergoing surgery.

The purposes of this retrospective study were to examine the efficacy of physical therapy using multimodal assessments and to evaluate which patients with LSS were satisfied with this type of therapy. Our hypothesis was that mental or psychological impairments would interfere with an optimal outcome possibly obtained by physical therapy in patients with LSS as well as preoperative depression status affects the postoperative outcomes.

Methods

This study was conducted at the Spine Care Center, Wakayama Medical University Kihoku Hospital. The ethics committee at Wakayama Medical University reviewed and approved the study. All patients provided informed consent before the procedures were initiated.

Patients diagnosed central LSS based on the clinical examination and MRI findings by one of two orthopaedic spine surgeons were enrolled from April 2011 to October 2012. The inclusion criteria were (1) Presence of neurogenic claudication; (2) presence of bilateral pain and/or numbness in the lower extremities with or without low back pain; (3) magnetic resonance imaging (MRI) or computed tomography-confirmed central stenosis with degenerative changes; (4) ≥50 years of age; (5) a history of ineffective responses to pharmacotherapy such as limaprost alfadex and Neurotropin® for more than 3 months. Patients with concomitant conditions that could compromise outcome assessment, such as trauma, osteoporosis, previous spine surgery, lateral root stenosis, degenerative scoliosis, spondylolisthesis with greater than 3 mm of slippage[16], cauda equina syndrome, peripheral artery disorders, osteoarthrosis of the knee and/or hip, diabetes mellitus, cognitive impairment, a history of psychiatric illness, and treatment with epidural steroid injection or selective nerve root injection, were excluded. Osteoporosis was judged when decrease in bone density was detected by plain lateral radiograph of the lumbar spine and the T score calculated by measured bone mineral density was less than − 2.5 SD [17].

Thirty-eight consecutive patients met the inclusion and exclusion criteria. Patients were evaluated prospectively at 6 weeks after intervention on the basis of a structured protocol established before patient enrollment. Patients were scheduled for 20 to 30 minute physical therapy sessions once a week for 6 weeks. In addition to the physical therapy visits, all patients were asked to take a daily walk at a pace and for a distance that did not irritate lower extremity symptoms and to perform a home exercise program consisting of flexion and strengthening exercises. Patients were treated with manual therapy, flexion and strengthening exercises for lumbar, abdominal, and leg muscles under the supervision of a physical therapist, and treadmill walking without weight bearing. A physical therapist performed the following manual therapies: stretching of the iliopsoas, hamstrings, quadriceps, and lumbar para

spinal muscles. The typical duration of stretching was 30 seconds. Flexion exercises included three 30 second bouts of both single and double knee-to-chest exercises. Patients' strengthening exercises were trunk raises and bridging in the supine position. The typical dosage for strengthening exercises was 10 repetitions, each of 6 seconds' duration [18]. Finally, patients participated in a body-weight-supported treadmill ambulation program. The amount of support used for each treadmill session was the minimum amount of unloading required to minimize the patient's symptoms and to allow the patient to walk as comfortably as possible [11,12]. The duration of the treadmill session was limited by participant tolerance or to a maximum of 10 minutes. Patients were allowed to receive 15 μg of limaprost three times a day and four tablets of an extract from cutaneous tissue of rabbit inoculated with vaccinia virus (Neurotropin®, Nippon Zoki Pharmaceutical Co., Osaka, Japan) twice a day. Limaprost is an oral Prostaglandin (PG) E1 derivative that was developed in Japan to treat ischemic symptoms of thromboangiitis obliterans and LSS because of the well-known vasodilatory and antiplatelet properties. PGE1 is a vasodilator that increases blood flow and inhibits platelet aggregation. The efficacy of oral limaprost was evaluated in adult Japanese patients [10]. Neurotropin which activates the descending inhibitory system from brain to peripheral nerve is used to relieve neuropathic pain [19]. Limaprost and Neurotropin have been used commonly in Japan to treat LSS.

Clinical outcomes were measured using the Zurich Claudication Questionnaire (ZCQ) [20,21] a visual analog scale (VAS) of low back pain, leg pain and leg numbness; the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ) [22-24] the Pain Catastrophizing Scale (PCS) [25,26] the Pain Anxiety Symptoms Scale (PASS-20) [27,28] the Hospital Anxiety and Depression Scale (HADS) [29,30] the Self-Rating Questionnaire for Depression (SRQ-D) [31,32] and a Biodex System 4 dynamometer at baseline and immediately after completion of 6 weeks program. Compliance with the home exercise program was measured using a self-report questionnaire. All questionnaires were self-administered and completed by the patients on their own at home. The completed questionnaires were collected and verified that no questionnaire had been left unanswered by 2 authors who were not involved in the treatments.

Measurements

▪ ZCQ: The ZCQ symptom severity subscale score ranges from 1 to 5 and the physical function subscale score ranges from 1 to 4, with higher scores indicating more severe symptoms. The ZCQ satisfaction subscale ranges from 1 to 4, with higher scores indicating more satisfaction with treatments. The ZCQ satisfaction subscale was modified from the original scale by replacing the word "surgery" with the word "rehabilitation" in each question. The ZCQ has demonstrated psychometric properties to be used in the outcome assessment of patients with LSS treated with both surgical and nonsurgical interventions [33,34]. The minimal clinically important difference for patients with LSS treated with nonsurgical interventions is 0.36 and 0.10 for symptom severity subscale and physical function subscale, respectively. We used the Japanese version [21].

▪ VAS: The VAS ranges from 0 to 100 mm, with higher scores indicating more severe symptoms. This has proved to be a valid index of experimental, clinical and chronic pain [35].

▪ JOABPEQ: The JOABPEQ consists of five factors: pain-related disorders, lumbar dysfunction, gait disturbance, social life dysfunction, and psychological disorders, and the range of the score for each domain is 0 to 100 points, with lower scores indicating more severe symptoms. The JOABPEQ has been shown to have good reliability and validity and could be used for the evaluation of lumbar disease [6,23,24].

▪ PCS: The PCS score ranges from 0 to 52, with higher scores indicating more frequent catastrophizing when experiencing pain. The PCS has been shown to have sufficient internal reliability, including the Japanese version [26].

▪ PASS-20: The PASS-20 score ranges from 0 to 100, with higher scores indicating higher pain anxiety or fear of pain. The Japanese version of the PASS-20 has been shown to be internally reliable [28].

▪ HADS: The HADS does not include somatic items, and the presence of bodily illness does not affect the scale scores. The HADS anxiety and depression subscales range from 0 to 21, respectively, with higher scores indicating higher severity. A score of 0 to 7 for either subscale could be regarded as being in the normal range, a score of 8 to 10 being suggestive of the presence of the respective state, and a score of 11 or higher indicating the probable presence of a mood disorder. The HADS has been found to have reliability and validity [29].

▪ SRQ-D: The SRQ-D includes many questions concerning depression-related physical symptoms, and is suitable for evaluating masked depression. The SRQ-D score ranges from 0 to 36, with higher scores indicating higher severity. A score of 10 points or less could be regarded as being in the normal range, a score of 10 to 15 being suggestive of the depression, and a score of 16 points or more indicating the probable presence of mild depression [32]. The SRQ-D has been found to have reliability and validity [36,37].

▪ Muscle strength of the trunk and knee joint were measured with the Biodex System 4 dynamometer. Patients were performed concentric contraction trunk and knee extension-flexion cycles at an angular velocity of 60°/s according to previous protocol [38,39]. The maximal isokinetic peak torque to body weight ratios (PT/BW) of trunk and knee extensor and flexor at 60°/s, were measured in order to be of some help to exam-

ine if our rehabilitation program had been carried out and was effective.

▪ Severity of the dura mater compression was evaluated from the MRI findings of the lumbar spine. MRI findings were examined using a 7-grade classification based on the morphology of the dural sac as observed on T2-weighted images of the lumbar axial spine [40]. Grades A1–A4 and B show the presence of cerebrospinal fluid while grades C and D show no fluid at all. Grade A was defined as no stenosis or a minor stenosis, B as moderate stenosis, C as severe stenosis, and D as extreme stenosis. Two orthopaedic spine surgeons, who were certified as a specialist by Japanese Orthopaedic Association and Japanese Society for Spine Surgery and Related Research Spine examined MRI findings and reached an agreement on the grade of the dura mater compression in all patients.

Data analysis

The outcome measures 6 weeks after the interventions were compared with those at the baseline in all patients according to Whitman's report [11]. In addition, in accordance with Stucki's criteria, for which a mean score of less than 2.5 in the satisfaction scores of the ZCQ subscales was defined as a successful outcome [20], patients were divided into two groups: the satisfied group (Group I) with mean score of less than 2.5, and the unsatisfied group (Group II) with a mean score of more than 2.5. The characteristics of patients with LSS who can obtain satisfactory results with our physical therapy programs were clarified (Figure 1).

Between-group comparisons of parametric variables were made using the Student's t test and nonparametric variables using Mann-Whitney U tests. Within-group changes in repeated measures were analyzed by using a paired t test or a Wilcoxon signed rank test as appropriate. All statistical tests were two-tailed, and the significance level was fixed at 0.05 throughout. All computations were performed using SPSS/PC (version 20.0., SPSS, Chicago IL).

Results

Thirty-eight patients were enrolled: 25 women and 13 men, with a mean age of 70.3 ± 7.6 years. Tables 1 and 2 summarize the results of all patients. All patients reported performing the home exercise program almost every day, except two who performed walking once every 2 days.

There were significant differences in the symptom severity on the ZCQ subscales (baseline, 3.1 ± 0.6 points; 6 weeks, 2.9 ± 0.7 points); the physical function on the ZCQ subscales (baseline, 2.3 ± 0.5 points; 6 weeks, 2.1 ± 0.6 points) and the PT/BW ratios (Nm/kg) of lumbar extensor at 60°/s (baseline, 129.5 ± 51.2 Nm/kg; 6 weeks, 183.9 ± 63.1 Nm/kg) and knee extensor at 60°/s (right knee extensor: baseline, 116.9 ± 52 Nm/kg, 6 weeks, 134.2 ± 55.2 Nm/kg; left knee extensor: baseline, 107.3 ± 45.4 Nm/kg, 6 weeks, 121.8 ± 43.8 Nm/kg). There were no significant differences in VAS of low back pain, leg pain, and leg numbness, and the points of the JOABPEQ subscales, the PCS, the PASS-20, the HADS, and the SRQ-D (Table 2).

Figure 1. Flowchart of the study.

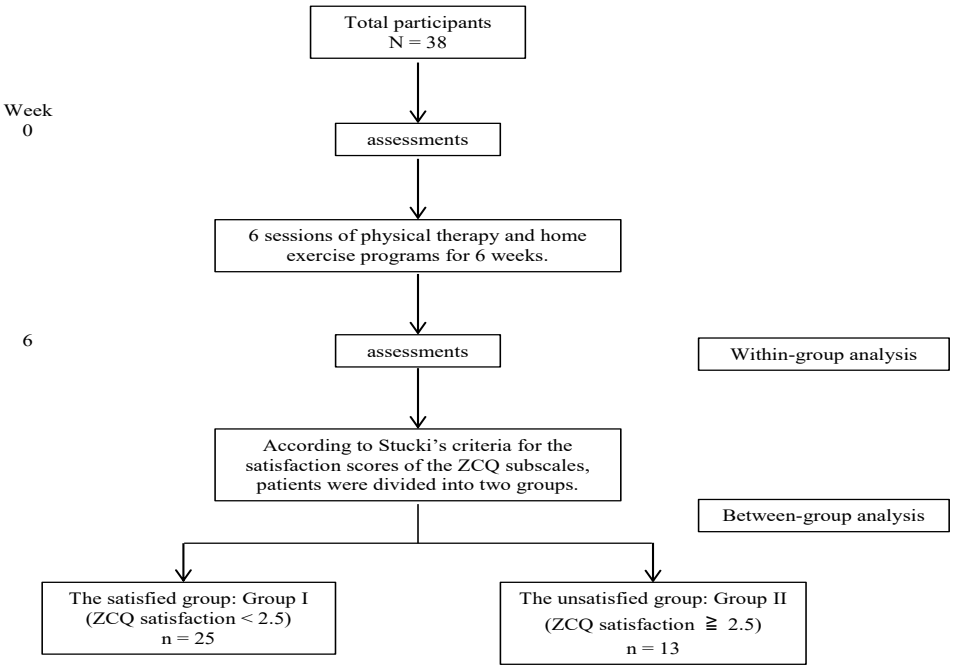

Table 1. Demographics of Patients

		Total (N = 38)
Age (year)		70.3 ± 7.6
Gender		Female: 25
		Male: 13
Body mass index (kg/m²)		22.3 ± 3.3
Duration of symptoms (months)		17.3 ± 20.9
Compliance with home exercise program (/42 days)		
Exercise		40.9 ± 2.6
Walking		38.5 ± 6.6
MRI (n = 35)		
L1-L2	Minor stenosis	35
	Moderate stenosis	0
	Sever stenosis	0
L2-L3	Minor stenosis	30
	Moderate stenosis	5
	Sever stenosis	0
L3-L4	Minor stenosis	21
	Moderate stenosis	12
	Sever stenosis	2
L4-L5	Minor stenosis	18
	Moderate stenosis	8
	Sever stenosis	9
L5-S1	Minor stenosis	35
	Moderate stenosis	0
	Sever stenosis	0

Values are mean ± SD.

Groups I and II had 25 and 13 patients, respectively. There were no differences in the demographic data including age, gender and duration of symptoms (Table 3), and MRI findings (Table 4) between the two groups. At baseline, however, there was a significant difference in the SRQ-D only between two groups (Group I, 7.2 ± 4.1 points vs. Group II, 10.9 ± 2.9 points) (Table 5-A).

At 6 weeks, there were significant differences in the SRQ-D (Group I, 6.8 ± 3.6 points vs. Group II, 12.2 ± 4.2 points); the physical function on the ZCQ subscales (Group I, 2 ± 0.5 points vs. Group II, 2.4 ± 0.6 points); the VAS of low back pain (Group I, 36.5 ± 27.5 mm vs. Group II, 62.3 ± 24.5 mm); the VAS of leg pain (Group I, 45.6 ± 26.7 mm vs. Group II, 70.5 ± 27.7 mm); the VAS of numbness (Group I, 48.8 ± 27.8 mm vs. Group II, 72.6 ± 15.1 mm); and the PCS (Group I, 22.2 ± 10.1 points vs. Group II, 32.1 ± 11.3 points). There were no significant

Table 2. Clinical Characteristics of Patients

	Total (N = 38)		
	Baseline	6 Weeks	P
ZCQ symptom severity	3.1 ± 0.6	2.9 ± 0.7	0.02 [1)]
ZCQ physical function	2.3 ± 0.5	2.1 ± 0.6	0.02 [1)]
VAS back pain	42.7 ± 24.9	45.3 ± 29	0.58 [1)]
VAS leg pain	60.6 ± 25.6	54.1 ± 29.2	0.44 [2)]
VAS numbness	60.6 ± 25.6	56.9 ± 26.6	0.40 [2)]
JOABPEQ pain-related disorders	52.9 ± 24.1	62 ± 30.4	0.10 [2)]
JOABPEQ lumbar dysfunction	72.1 ± 19.9	77.2 ± 18.1	0.07 [2)]
JOABPEQ gait disturbance	44.3 ± 26.3	49.4 ± 27.8	0.33 [2)]
JOABPEQ social life dysfunction	54.4 ± 18.2	54.1 ± 17.8	0.83 [2)]
JOABPEQ psychological disorders	51.1 ± 14.3	52.9 ± 14.2	0.44 [2)]
PCS	28.3 ± 10.1	25.6 ± 11.4	0.08 [1)]
PASS-20	35.9 ± 16.1	35.4 ± 16.3	0.82 [1)]
HADS anxiety	4.7 ± 3	4.7 ± 2.9	0.99 [2)]
HADS depression	5.1 ± 2.7	4.9 ± 3.5	0.77 [1)]
SRQ-D	8.5 ± 4.1	8.7 ± 4.6	0.70 [1)]
BIODEX60°Nm/kg lumbar extensor	129.5 ± 51.2	183.9 ± 63.1	0.00 [1)]
BIODEX60°Nm/kg lumbar flexor	94.6 ± 30.6	100.6 ± 36.5	0.45 [1)]
BIODEX60°Nm/kg right knee extensor	116.9 ± 52	134.2 ± 55.2	0.01 [1)]
BIODEX60°Nm/kg right knee flexor	56 ± 27.8	58.3 ± 23.4	0.62 [1)]
BIODEX60°Nm/kg left knee extensor	107.3 ± 45.4	121.8 ± 43.8	0.00 [1)]
BIODEX60°Nm/kg left knee flexor	53.6 ± 28.9	61 ± 26.3	0.05 [1)]

Values are mean ± SD, [1)]Paired t test, [2)]Wilcoxon signed rank test, ZCQ, Zurich Claudication Questionnaire; VAS, Visual Analog Scale; JOABPEQ, Japanese Orthopedic Association Back Pain Evaluation Questionnaire; PCS, Pain Catastrophizing Scale; PASS-20, Pain Anxiety Symptoms Scale; HADS, Hospital Anxiety and Depression Scale; SRQ-D, Self-Rating Questionnaire for Depression.

Table 3. Comparison of Demographics of Patients

	Group I (n = 25)	Group II (n = 13)	P
Age (year)	70.1 ± 7.4	70.8 ± 8.3	0.77 [1)]
Gender	Female: 16	Female: 9	0.75 [2)]
	Male: 9	Male: 4	
Body mass index (kg/m²)	21.8 ± 2.9	23.4 ± 4	0.19 [1)]
Duration of symptoms (months)	15.1 ± 20.5	21.8 ± 22.1	0.31 [3)]
Compliance with home exercise program (/42 days)			
Exercise	40.8 ± 2.9	41.8 ± 0.5	0.89 [3)]
Walking	38.2 ± 7.1	40.5 ± 3	0.64 [3)]

Values are mean ± SD, [1)]Student's t test, [2)]Fisher's exact test, [3)]Mann–Whitney U test

Table 4. Number of Patients with Spinal Stenosis at Each Spinal Level

	Group I (n = 22)			Group II (n = 13)			P
	Minor stenosis	Moderate stenosis	Severe stenosis	Minor stenosis	Moderate stenosis	Severe stenosis	
L1–L2	22	0	0	13	0	0	0.49
L2–L3	18	4	0	12	1	0	0.62
L3–L4	14	7	1	7	5	1	0.55
L4–L5	13	5	4	5	3	5	0.49
L5–S1	22	0	0	13	0	0	0.43

Mann–Whitney *U* test

Table 5-A. Comparison of clinical characteristics between the Group I and II at baseline.

	Group I (n = 25)	Group II (n = 13)	P
ZCQ symptom severity	3 ± 0.6	3.3 ± 0.5	0.09 [1)]
ZCQ physical function	2.2 ± 0.5	2.5 ± 0.4	0.09 [1)]
VAS back pain	42.4 ± 24.6	43.2 ± 26.4	0.86 [1)]
VAS leg pain	57.8 ± 27.4	65.8 ± 26.4	0.61 [1)]
VAS numbness	59.1 ± 24.5	63.6 ± 28.2	0.58 [1)]
JOABPEQ			
pain-related disorders	58.4 ± 23.4	45 ± 23.9	0.14 [2)]
lumbar dysfunction	73.2 ± 18.9	70.3 ± 22.5	0.74 [2)]
gait disturbance	47.8 ± 25	38.5 ± 28.3	0.21 [2)]
social life dysfunction	59.1 ± 17.1	45.5 ± 17.4	0.06 [2)]
psychological disorders	53.5 ± 15.3	46.5 ± 11.1	0.23 [2)]
PCS	27.2 ± 10.1	30.5 ± 10.3	0.13 [2)]
PASS-20	35 ± 17.9	37.6 ± 12.2	0.65 [1)]
HADS anxiety	4.6 ± 2.9	5 ± 2.9	0.64 [2)]
HADS depression	5.1 ± 2.6	5 ± 3.3	0.99 [2)]
SRQ-D	7.2 ± 4.1	10.9 ± 2.9	0.01 [1)]
BIODEX60°Nm/kg lumbar extensor	128.1 ± 53.8	134.1 ± 46.6	0.74 [1)]
BIODEX60°Nm/kg lumbar flexor	93.7 ± 25.5	97.7 ± 47.9	0.23 [1)]
BIODEX60°Nm/kg right knee extensor	118.3 ± 52.8	112.2 ± 55	0.27 [1)]
BIODEX60°Nm/kg right knee flexor	57.7 ± 27.7	50.4 ± 30.6	0.13 [1)]
BIODEX60°Nm/kg left knee extensor	109.1 ± 49.6	101.3 ± 30.4	0.15 [1)]
BIODEX60°Nm/kg left knee flexor	56.4 ± 29.6	44.3 ± 27.3	0.10 [1)]

Values are mean ± SD, [1)]Student's t test, [2)]Mann–Whitney *U* test, ZCQ, Zurich Claudication Questionnaire; VAS, Visual Analog Scale; JOABPEQ, Japanese Orthopedic Association Back Pain Evaluation Questionnaire; PCS, Pain Catastrophizing Scale; PASS-20, Pain Anxiety Symptoms Scale; HADS, Hospital Anxiety and Depression Scale; SRQ-D, Self-Rating Questionnaire for Depression.

differences in the symptom severity on the ZCQ subscales, the acquired points of the JOABPEQ subscales, PASS-20, HADS and PT/BW of trunk and knee extensor and flexor at 60°/s between the Group I and II (Table 5-B).

Table. 5-B. Comparison of clinical characteristics between the Group I and II 6 weeks after intervention

	Group I (n = 25)	Group II (n = 13)	P
ZCQ symptom severity	2.8 ± 0.7	3.1 ± 0.7	0.25 [1)]
ZCQ physical function	2 ± 0.5	2.4 ± 0.6	0.02 [1)]
VAS back pain	36.5 ± 27.5	62.3 ± 24.5	0.01 [1)]
VAS leg pain	45.6 ± 26.7	70.5 ± 27.7	0.02 [2)]
VAS numbness	48.8 ± 27.8	72.6 ± 15.1	0.01 [1)]
Acquired points of JOABPEQ subscales			
pain-related disorders	13.7 ± 24	2.5 ± 29.2	0.45 [1)]
lumbar dysfunction	6.7 ± 16.3	2.2 ± 14.6	0.46 [1)]
gait disturbance	11.6 ± 28	–5.5 ± 29.7	0.10 [1)]
social life dysfunction	–1.1 ± 16.2	1.1 ± 16	0.69 [1)]
psychological disorders	2 ± 12.8	1.3 ± 14.3	0.87 [1)]
PCS	22.2 ± 10.1	32.1 ± 11.3	0.01 [1)]
PASS-20	33.1 ± 17.9	39.9 ± 11.8	0.23 [1)]
HADS anxiety	4.1 ± 3	5.8 ± 3.6	0.16 [2)]
HADS depression	4.1 ± 3	6.5 ± 4	0.05 [1)]
SRQ-D	6.8 ± 3.6	12.2 ± 4.2	0.00 [1)]
BIODEX60°Nm/kg lumbar extensor	181.6 ± 57.8	191.5 ± 86.4	0.93 [1)]
BIODEX60°Nm/kg lumbar flexor	97.9 ± 29.9	109.8 ± 57.2	0.92 [1)]
BIODEX60°Nm/kg right knee extensor	135.4 ± 56.7	129.9 ± 55.9	0.82 [1)]
BIODEX60°Nm/kg right knee flexor	60.6 ± 22	50.6 ± 29	0.30 [1)]
BIODEX60°Nm/kg left knee extensor	122.9 ± 47.1	117.9 ± 34.5	0.52 [1)]
BIODEX60°Nm/kg left knee flexor	63.4 ± 26.4	52.6 ± 26.9	0.35 [1)]

Values are mean ± SD, [1)]Student's t test, [2)]Mann–Whitney *U* test, ZCQ, Zurich Claudication Questionnaire; VAS, Visual Analog Scale; JOABPEQ, Japanese Orthopedic Association Back Pain Evaluation Questionnaire; PCS, Pain Catastrophizing Scale; PASS-20, Pain Anxiety Symptoms Scale; HADS, Hospital Anxiety and Depression Scale; SRQ-D, Self-Rating Questionnaire for Depression.

Discussion

Twenty-five of 38 (66%) patients reported being satisfied with treatment in the satisfaction domain of the ZCQ questionnaire. Zucherman et al [41] compared surgery with non-surgical treatment including physical therapy in patients with LSS. At the 6 weeks follow-up period, approximately 75% of the surgery and 45% of the nonsurgical patients were satisfied with treatment in the satisfaction domain of the ZCQ questionnaire. Therefore, our physical therapy results in the relative-

ly high degree of satisfaction. Our study shows a significant improvement in physical function consistent with previous studies [11-15]. The mean improvement in physical function as measured by the ZCQ was beyond the minimal clinically important difference of 0.10 [34]. In addition to physical function, there were significant improvements in the muscle strength of the trunk and knee extensors. Increasing the level of physical activities after an improvement in walking capacity promotes sequential improvements in the antigravity muscle strength of the trunk and knee joint. This might be part of the reason for the improvement of muscle strength. However, there were no significant improvements in low back pain and leg pain, which was inconsistent with previous studies. In previous studies, 10 to 15 sessions of the physical therapy programs were conducted. Whitman et al [11] and Pue et al [12] performed physical therapy twice a week for 6 weeks for outpatients. Sahin et al [13], Koc et al [14], and Goren et al [15] performed physical therapy five times a week for 2 to 3 weeks for inpatients. Our study was conducted once a week for 6 weeks for a total of 6 sessions. This may not be enough sessions to show improvement in low back pain and leg pain.

When comparing our two groups, there were clear differences in the SRQ-D score between the satisfied group (Group I) and the unsatisfied group (Group II) before treatments. The patients in Group II had high levels of masked depression at baseline and 6 weeks after treatments, but there were no significant differences in demographic data, MRI findings, severity of pain, disability, and psychological factors, which were measured by points of psychological disorders in the JOABPEQ, PCS, PASS-20 and HADS, at baseline in the present study. Linton [42] has suggested that psychological factors, such as depression and anxiety, are associated more strongly with adverse pain outcomes rather than with clinical factors, such as radiographic findings. Several studies and reviews have assessed the impact of depression on pain outcomes. They have established that concurrent depression and pain have a much greater impact than either disorder alone [43,44]. In patients with pain, depression is associated with more pain sites, greater pain intensity, longer duration of pain, and a greater likelihood of poor treatment response [44]. In patients with LSS treated with surgery, Sinikallio et al [8,45] reported that preoperative depression status affects the postoperative outcome significantly at 3 months and 2 years after surgery. Collectively, these reports suggest that elevated levels of depressed mood are useful indicators of an increased risk for unfavorable outcomes with regard to physical therapy for patients with LSS.

In the present study, we used two different evaluation questionnaires for depression. There was a significant difference in the SRQ-D between Groups I and II but no difference in depression on the HADS subscales. Furthermore, the depression levels measured by the HADS in Group II were below the recommended cutoff of 8 points for possible cases of depression [29]. However, depression levels measured by the SRQ-D in Group II were beyond the recommended cutoff of 10 points for possible cases of depression [32]. The presence of bodily illness does not affect the HADS depression subscales, whereas the SRQ-D includes questions concerning depression-related physical symptoms and is suitable for evaluating masked depression. Masked depression is a condition in which the classic affective and cognitive symptoms of depression are hidden behind a variety of somatic complaints, such as headaches, and abdominal or other pain and is regarded as minor depression [46,47]. There is certainly an overlap of symptoms between depression and somatization [48]. Simon et al [49] noted that half the depressed patients reported multiple, unexplained somatoform symptoms. On the other hand, previous research has shown that sub threshold depressive symptoms have various adverse effects, such as increased risks of functional, health, and mood impairment [50,51]. Therefore, if there is masked depression without a major depressive disorder, it may interfere with the ability of LSS patients to obtain an optimal physical therapy outcome.

Our study contains some limitations. First, the sample size may have been insufficient for a rigorous statistical analysis to detect true differences between the groups. Second, there are no data regarding the long-term follow-up of the patients. Future trials with longer follow-up periods are required to establish whether the interventions used in our study would result in the long-term improvement of symptoms and decrease the patients undergoing surgery. Long-term follow-up data are currently being collected. Third, because of lack of a control group, it is difficult to identify whether our study intervention or natural history affected patient's physical function and muscle strength. Furthermore, the improvement in some study parameters observed in the present study might be related to the exercise program in addition to oral medication, such as limaprost and Neurotropin®. However, it was considered unethical to keep the patients without pain medication and exercise during management of this painful chronic condition. Therefore, we recruited patients who had received oral medication before participation. Fourth, we used only two depression assessments and only one of two depression scales among several psychological scales detected a significant difference between Groups I and II at baseline. However, there are no previous studies examining psychological factors among patients with LSS treated with physical therapy. Future trials should include strict assessments of psychological factors. Finally, we divided patients into two groups based on Stucki's criteria, for which a mean score of less than 2.5 in the satisfaction scores of the ZCQ subscales was defined as a successful outcome. However, the characteristics of the satisfaction subscale have been investigated in only a single large prospective observational study of patients undergoing decompressive surgery for LSS [16]. The properties of this satisfaction subscale among patients with LSS undergoing nonsurgical treatments are unknown.

Conclusion

In conclusion, the short-term physical therapy programs provided by the authors resulted in a significant improvement in the physical function and muscle strength of patients with LSS. Twenty-five of 38 patients were satisfied with treatment in the satisfaction domain of the ZCQ questionnaire. We found that the SRQ-D points in the satisfied patients were statistically lower than those in the unsatisfied patients, both at baseline and 6 weeks after the intervention. Collectively, these results suggest that assessments and treatment of masked depression are needed to improve the short-term outcomes of physical therapy for patients with LSS.

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