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ABSTRACT

Study Design: A randomized clinical trial. **Background and Purpose:** Several exercise programs have been reported to be beneficial in the treatment of low back pain (LBP). This study was to examine two different exercises, thoracolumbar exercise (TLE) and lumbar stabilizing exercise (LSE), for LBP. **Methods:** Ninety subjects (42 male, 48 female), who had mechanical LBP without other neurological symptoms, were exercised for 40 minutes, 3 times/week, for 8 weeks. This trial examined the Oswestry Disability Index, pain, static standing balance, thoracic mobility, and lumbar flexibility. **Results:** Subjects who participated in the TLE program were better than the LSE on the Oswestry Disability Index, thoracic mobility, and static standing balance. However, subject performances did not significantly differ in either exercise group in terms of pain and lumbar flexibility. **Discussion:** The TLE program has been demonstrated to be effective in patients with LBP in terms of lumbar functional disability including static standing balance.

Key Words: thoracolumbar exercise, low back pain, static standing balance

INTRODUCTION

The costs attributable to low back pain (LBP), one of the most common forms of chronic musculoskeletal problems, continue to increase and the recurrence rate is from 60% to 86% in an industrial setting.[1-2] Several researches[3-7] were reported to have identified the factors of LBP occurrences. It has been found that unexpected movement, especially rotation, lifting a heavy load, and stress, in several muscles of spinal segments has been related to LBP.[8] For LBP, the instability at the spinal segmental level has been proposed to be the loss of control or hypermobility in the spinal segment that is associated with compensation of hypomobility joints and muscle weakness.[2,9,10] Also, the limitation of thoracic movement has caused compensatory motion that provided pain at the cervical and lumbar segmental level in persons who had thoracic stiffness, increased kyphotic curve, or a sedentary life style.[9,11-13]

In the majority of cases, LBP requires long-term treatment. Therefore, effective management to relieve symptoms and prevent a chronic condition becomes an important issue. Recent research has focused on the role trunk muscles play in lumbar support. A study by Brontfort et al[14] showed that patients who received supervised trunk exercise were most satisfied with care and increased trunk muscle endurance and strength both over a short- and long-term time period. Core muscles attached to the spine such as transversus abdominis, multifidus, and the erector spinae provide stabilization by forming a corset around the spine.[15,16] The dysfunction of multifidus tends to increase symptoms and the recurrence rate of LBP.[17-19] Thus, specific exercise based on the transversus abdominis muscle and lumbar multifidus has been shown to decrease pain and disability[20] and specific exercise of multifidus has been shown to decrease recurrence of LBP in one to 3 years of follow-up after treatment.[2] Another specific exercise for thoracic mobility was used to decrease compensatory motion of lumbar segments[12] and improve the lumbar mechanical stability that is such an important factor of LBP.[21] However, although the loss of thoracic motion has been shown to trigger the overuse and loss of control in the lumbar region,[10] most exercise studies that have been published relate LBP to the activation of lumbar muscles. The purpose of this study was to compare the effect of an active thoracolumbar exercise program with a lumbar stability program in the treatment of patients with LBP on pain, disability index, thoracic mobility, lumbar flexibility, and static balance.

Symptoms of a back problem include limited range of motion (ROM), loss of flexibility and balance, decreased endurance, as well as an increase of pain. Other studies on balance reactions using subjects with LBP have shown that postural sway was significantly greater and that the patients kept their body center of gravity more posterior compared to a healthy population.[22,23] The review by Mann et al[24] presented significantly higher amplitudes of center of pressure (CoP) for anterior-posterior direction during standing and the velocity of CoP was larger for subjects with LBP when compared to a healthy back group. As with previous studies, LBP influenced balance in quiet standing. The purpose of this study was to investigate the effect of both spine exercises on body balance during standing in subjects with LBP. In order to study the static standing balance in this study, we used a portable force platform because it represents a more practical and time-efficient technique for use in a clinical setting.

METHODS

Participants

A total of 258 participants who were recruited through visits at the hospital rehabilitation center in Seoul, Korea, volunteered in this study. However, 161 subjects were excluded due to involving the other orthopaedic conditions or surgery, incomplete data collection, or refusing participation during baseline assessment. Seven subjects had other reasons for not participating. Of the remaining 90 subjects (42 male, 48 female), 45 were randomly assigned to the thoracolumbar exercise (TLE) group and 45 were randomly assigned to the lumbar stability exercise (LSE) group. Eligible participants included individuals between the ages of 20 and 30 who had a primary complaint of mechanical LBP and were admitted by interview and questionnaire. Mechanical LBP was defined as pain that had no specific identifiable etiology but that could be reproduced by specific back movements. The exclusion criteria were rheumatologic conditions, other orthopaedic disease or pathologic conditions, previous lumbar surgery, neurological symptoms in lower extremities, and current pregnancy. All the procedures were explained to the subject before the study and we obtained informed consent from each subject, as appropriate.

Interventions

The study was a randomized clinically controlled study. All of the subjects were receiving conservative physical therapy for complaints of LBP including 15 minutes of hot pack and 15 minutes of electrotherapy.

After finishing traditional therapy, members in either the TLE group or LSE group were required to perform each prescribed exercise for 40 minutes, 3 days a week, over a period of 8 weeks. All patients were individually instructed to perform the following exercises by an experienced physical therapist (Appendix 1). The TLE program was based on McKenzie extension exercise and specific training for improvement of thoracic mobility. The LES program was based on William flexion exercise and specific training of transversus abdominis muscle with co-activation of lumbar multifidus at lumbosacral region. Each exercise program was composed of 3 stages; the warm-up stage for 5 minutes, main stage was formed for 4 different exercises (TLE: trunk rotation, thoracolumbar extension exercise in prone, supine, and sitting; LSE: pelvic tilting, bridge, kneeling opposites, and bent-knee leg lift), and cool-down stage for another 5 minutes. The main focus of the exercise programs was individualized in terms of intensity such as repetitions of set according to the patients` abilities. The patients were instructed to perform repetitions of the main exercise for 30 minutes or until they could no longer do so using proper form, or they experienced back pain during the intervention period.

The assessment of both groups was performed by one independent examiner who was blinded to group allocation and presentation. The following tests were conducted to establish a baseline level and to monitor improvement of symptoms: disability (Oswestry LBP Disability Index), pain (Visual Analog Scale), static standing balance (using Gaitview AFA-50 system, alFOOTs Co, Ltd, Seoul, Republic of Korea), thoracic mobility (Thoracic Mobility Test), and lumbar flexibility (Skin Distraction Test).

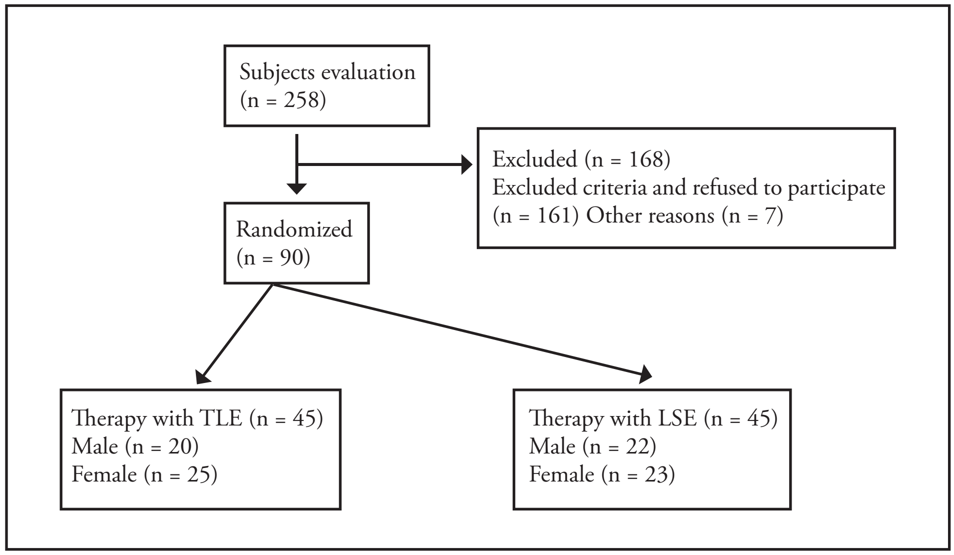

Figure 1. Subject flow chart.

Outcome Measures

The main outcome measures were administered at the time of pre-exercise, 4 weeks after completion of the exercise period, and again 8 weeks after the end of the session. For rating the severity of LBP, each subject completed the Oswestry LBP disability index, which is a self-report questionnaire using 10 questions that addresses pain, personal care, and activities of daily living (ADL) including lifting, walking, sitting, standing, sleep, sexual and social activities, and travel. The subjects provided a score from zero (no pain) to 5 (worst pain) to indicate intensity of pain. The disability index result was explained by percentage (%). The reliability of Oswestry LBP disability index has been previously found to be .99.[25] Patient-rated pain was measured using a visual analog scale. The subjects were asked to rate their level of back pain on a zero to 10 scale, with zero representing "no pain" and 10 being "worst pain possible." The CoP excursion was tested using a portable force platform (Gaitview). During the measurement of static standing balance, the subjects were instructed to look straight ahead and stand as still as possible in the center of the platform. The area of CoP trajectory (mm^2) was examined for 30 seconds with eyes closed. For thoracic mobility assessment, our thoracic mobility test was defined as, the amount of thoracic spine motion as the length from heel to tip of middle finger while each subject maintained the normal lumbar lordotic curve and raised up their arms as much as possible. The outcome was recorded as the percent change in height from standing height (%). Subjects repeated the mobility test 3 times to obtain the mean of thoracic extension. Lumbar flexibility was assessed using the skin distraction test; the examiner obtained the length from C7 to S1 spine midline landmarks. Measurements were taken in both an upright standing position (initial) with arms crossed over their chest and fully flexed (final) postures. Between-measurement differences were then calculated and expressed as a percentage (%).

Statistical analysis

The data was analyzed using statistical software SAS for Windows 9.1. Means and standard deviations were calculated. An independent t-test was used to compare subjects' characteristics between groups. A repeated measure analysis of variance (ANOVA) with one within-subjects factor (condition: pretest, 4 weeks, and 8 weeks) and one between-subject factor (group: 2 difference exercise) was used to determine the main effects and the interaction for each tested method. The level of significance was set at $p < .05$.

RESULTS

Ninety subjects who met subject criteria were randomized for this study from a total of 258 subjects. A summary of participants is shown in Figure 1. All randomized subjects` characteristics are represented in Table 1. There was no statistical difference between groups for interventions ($p > .05$).

Table 1. Subjects' Characteristics

	TLE	LSE	p value
Sex			
Male	20 (44.4%)	22 (48.9%)	
Female	25 (55.6%)	23 (51.1%)	0.832
Age (yrs)			
20 years	21 (46.7%)	23 (51.1%)	
30 years	24 (53.3%)	22 (48.9%)	0.833
Height (cm)	166.8 ± 7.5	166.1 ± 7.6	0.646
Weight (kg)	64.5 ± 12.7	65.0 ± 11.2	0.820
BMI			
22 >	20 (44.4%)	15 (33.3%)	
22 ≤ BMI < 25	8 (17.8%)	12 (26.7%)	0.462
25 ≤	17 (37.8%)	18 (40.0%)	
Working period (months)	23.7 ± 17.7	30.6 ± 24.6	0.131
Intensity of working			
Office job	11 (24.4%)	14 (31.1%)	
Light work	12 (26.7%)	11 (24.4%)	0.779
Heavy work	22 (48.9%)	20 (44.4%)	
Type of working			
Full time	38 (84.4%)	36 (80.0%)	
Independent worker	6 (13.3%)	4 (8.9%)	0.210
Per diem	1 (2.2%)	5 (11.1%)	

TLE= thoracolumbar exercise, LSE=lumbar stabilizing exercise, BMI=body mass index

Table 2. Patient-rated Outcomes at Each Measurement Period

	Baseline	4 weeks	8 weeks	adjusted p value
Oswestry LBP Disability Index				0.018*
TLE	32.97 ± 9.81	21.51 ± 7.61	11.89 ± 6.58	
LSE	30.25 ± 10.63	21.17 ± 8.53	13.54 ± 7.67	
Thoracic mobility (%)				0.001*
TLE	0	1.18 ± 1.56	1.78 ± 1.51	
LSE	0	0.77 ± 0.48	0.76 ± 0.54	
Static standing balance				0.033*
TLE	6.02 ± 1.73	3.24 ± 1.23	1.18 ± 0.63	
LSE	5.64 ± 1.93	2.91 ± 1.33	1.51 ± 0.87	
Visual analog scale				0.403
TLE	5.87 ± 0.99	4.02 ± 1.12	2.02 ± 0.94	
LSE	5.84 ± 0.95	4.27 ± 1.03	2.27 ± 0.94	
Lumbar flexibility (%)				0.404
TLE	0	32.55 ± 14.31	60.65 ± 21.55	
LSE	0	30.54 ± 17.43	55.38 ± 26.33	

LBP=low back pain, TLE=thoracolumbar exercise, LSE=lumbar stabilizing exercise
*$p < .05$

The patient-rated outcomes for each measurement period are shown in Table 2. Both groups demonstrated improved outcomes throughout the 8-week treatment period. Results of the repeated measures ANOVA showed statistically significant improvements ($p < .05$) in intervention effects for the TLE group on Oswestry LBP disability index score, thoracic mobility, and static standing balance. There were no statistically significant differences between groups for pain and lumbar flexibility.

DISCUSSION

The main finding of this study was that the TLE group performing thoracic mobility exercise was considerably more effective in increasing thoracic mobility (%), improving static standing balance, and scoring more favorably on the Oswestry Disability Index compared to patients with LBP who were in the LSE group. This study used the length of the standing body to evaluate the thoracic movement as previously described by Yang et al.[26] In both exercise groups, the pain scale was decreased and lumbar flexibility was increased; the TLE group showed more improvement, but the differences were relatively small and not statistically significant.

Recent studies have reported that LBP is caused by a deficient stabilization of lumbar segments or a decreased strengthening of the trunk extensors and flexors.[27-31] Trunk flexor weakness may reduce spinal stability by not providing adequate intra-abdominal pressure.[31] In addition, previous reviews have suggested that back muscle strengthening is important to protect the lumbar segmental function.[2,14,15,21,32] In the current study, two different randomized groups performed exercises that were intended to strengthen the superficial muscles of abdomen and trunk in patients with LBP. For the results of pain and functional impairment, our findings are supported by other studies. The study by França et al[21] reported that segmental stabilization (transversus abdominis and lumbar multifidus) and superficial strengthening (rectus abdominis, external and internal oblique, and erector spinae) exercises were effective in relieving pain and decreasing functional disability. In a study by Bronfort et al,[14] the group involved in supervised trunk exercise therapy showed more improvement than the group receiving spinal manipulative therapy or home exercise on the variables of trunk strength and endurance at short- and long-term (52 weeks) outcomes. However, many authors reviewed the specific exercise of lumbar segments for LBP to determine whether to increase abdominal/back muscle strengthening or to stabilize lumbar/sacroiliac segments.[2,20,21,29,33] Our study demonstrated increases in thoracic mobility in order to compensate for the deficiency in lumbar segment motion. The TLE group was shown to have better improvement in our measures of functional ability. Our result demonstrated that the abnormal movement control of other relative segments may also be used as a method for increasing lumbar stability.[34,35] Improvement among the LSE group was also shown and supported in previous studies.[33,36]

There is also an association between body balance reactions and lower back pain. Byl et al[37] explained that body sway was higher in the LBP group compared with the healthy back group under different balance conditions and LBP subjects have more difficulty in maintaining balance using a conservative strategy. For balance, patients with LBP had delayed muscle response times in an unstable sitting situation.[38] Postural alignment and balance responses have been accounted for by various systems (ie, visual, proprioceptive, and vestibular.). In particular, visual input has been found to have the most effect on body sway to maintain the upright position.[39] The current study excluded visual control (eyes closed) while balancing on a standing fulcrum. The LBP group showed larger amplitudes of body sway from a hip/back strategy to ankle strategy in order to relieve back stress.[22] Our study findings suggest that back specific exercise, especially thoracic mobility exercise, which entailed moving the trunk on the extremity, resulted in a reduction in body sway. Further studies are needed to determine the exact mechanisms through which TLE enhances the balance activities.

In our study, we limited the outcome measurements to the thoracic mobility test and lumbar flexibility test. More evidence using a larger study population is required to further substantiate the findings of this study. Also, a limitation of this study is the lack of blinding of the potential impact only for thoracic mobility because exercises were influenced by the global mobility of entire spine segments. As a result, further investigation is needed to identify more specific elements in thoracic mobility exercise of an individualized program in patients with lower back pain. In fact, a long-term follow-up study of the TLE is needed to evaluate the importance of specific thoracic exercise and its inclusion to lower-back exercise programs in clinic.

CONCLUSION

The results of this study suggest that specific exercise that includes thoracolumbar mobility exercises is more effective in reducing LBP, improving thoracic mobility, static standing balance, and functional abilities compared to a lumbar stabilization program.

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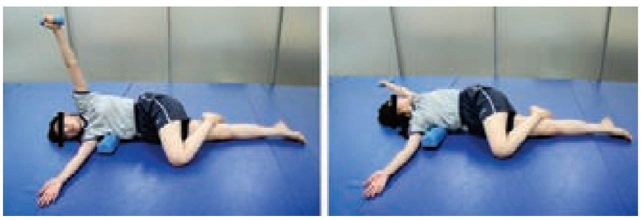
Appendix 1. Method of the Exercise Program

Group 1. Thoracolumbar Exercise Group

Trapezius and levator stretch

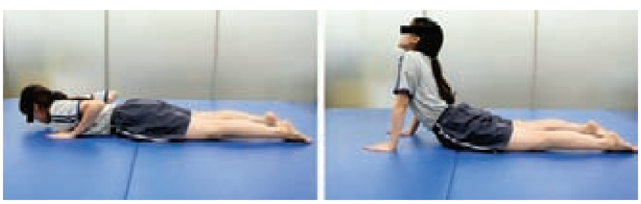
Method

The subject was instructed to hold this stretch for 10 seconds.



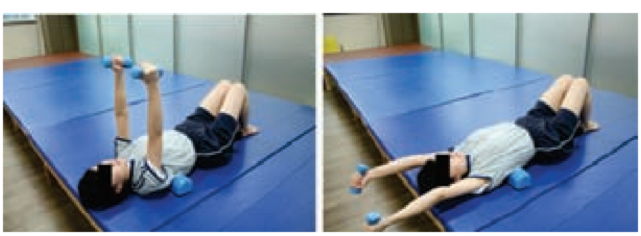
Trunk rotation exercise

To start, the subject was required to lie on her right side with a roll on the thoracic area placing the bent left leg over the right leg. The subject then placed her extended right arm to the side while holding a 1 kg dumbbell in her left hand. For trunk rotation, the subject slowly moved her left arm and neck to the left side without rotating the pelvis and leg. The position was held for 10 seconds. This motion was repeated in the opposite direction. The subject was instructed to breathe freely and deeply throughout the exercise and keep her abdominal muscles tight. The motion was repeated 10 times with 5 seconds rest between each session.



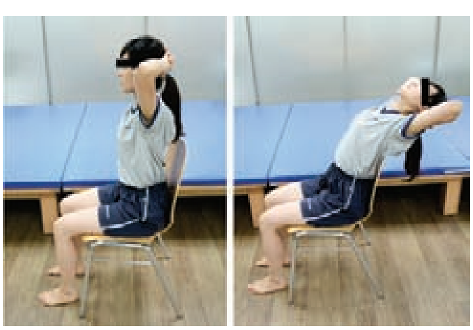
Thoracolumbar extension exercise in prone

At the starting position, the subject lies down on her stomach with her toes touching the floor. Lift chest with support of both hands and extend head and trunk, while maintaining the straight line from hand to shoulder. The position was held for 10 seconds and then return to the starting position. This motion was repeated 10 times with 5 seconds rest between each session.



Thoracolumbar extension exercise in prone

The subject lies down and bends knees with feet flat on the floor. Subject holds 1 kg dumbbell in each hand and places a roll on the thoracic area. Slowly move both shoulders from 90° to 180° flexion and maintain extension of elbow. The position is held for 10 seconds and then return to the starting position. The subject breathes freely and deeply throughout the exercise and keeps abdominal muscles tight. The motion was repeated 10 times with 5 seconds rest between each session.



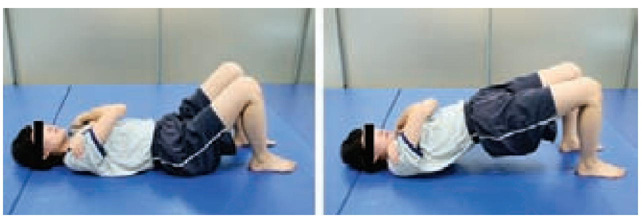
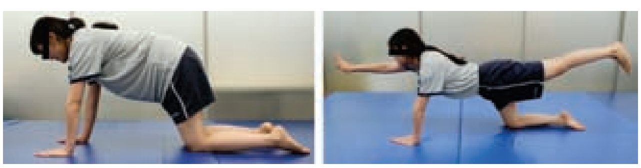
Thoracolumbar extension exercise in sitting

At the neutral sitting position on a chair with a back rest, subject places hands on her occiput. Slowly extend the trunk only and maintain chin-tuck position while subject exhales. Do not extend neck. Hold the position for 10 seconds and then return to the starting position. The motion was repeated 10 times with 5 seconds rest between each session.

Follow-up: Treadmill

The subject walks on the treadmill at a speed of 1.0-3.0 km/h for 5 minutes.

Appendix 1. Method of the Exercise Program (continued)

Group 2: Lumbar Stabilizing Exercises	Method
 **Hamstring stretch**	At the starting position, the subject lies down on the floor, and then slowly bends the right knee grabbing the back of thigh with both hands. The subject pulls the leg towards her chest gently, keeping the left leg extended and both hips on the floor. The position was held for 10 seconds. This motion was repeated on the opposite side and then returned to the starting position. The motion was repeated 10 times with 5 seconds rest between each session.
 **Pelvic tilting exercise**	For the pelvic tilt, the subject was required to lie on her back, bend knees, with feet flat on the floor. The subject then flattened the curve of her back and simultaneously tightened her buttocks and abdomen. This position was held for 10 seconds and then return to the starting position. The motion was repeated 10 times with 5 seconds rest between each session.
 **Bridge exercise**	To start, the subject lies down, crosses her arms on the chest, bend knees with feet placed flat on the floor. During the motion, press the heels into the floor and squeeze the gluteals and contract the abdominals while lifting the pelvis. The subject holds the position for 10 seconds and then returns to starting position. The motion was repeated 10 times with 5 seconds rest between each session.
 **Kneeling opposites**	At the starting position, the subject kneels on the floor and places her hands below shoulders and knees below hips. The subject extends left leg backward and the right arm forward sim-ultaneously while tightening the gluteal and abdominal muscles and keeping the spine as straight as possible. Hold a straight line from hand to shoulder, shoulder to hip, and hip to foot for 10 seconds. The motion is repeated with opposite limbs. Subject breathes freely and deeply throughout the exercise and keeps abdominal muscles tight. The motion is repeated 10 times with 5 seconds rest between each session.
 **Bent-knee leg lift**	To start, the subject lies down and bends her knees with feet placed flat on the floor. The subject then raises one leg towards her chest to keep the knee in a bent position until the hip is in 90° flexion and simultaneously pushes the knee with both hands. Perform a slight curl or crunch by contracting the abdominal muscles. This position was held 10 seconds. This motion was repeated with the opposite leg and then return to starting position. This motion was repeated 10 times with 5 seconds rest between each session.
Follow-up: Treadmill	The subject walks on the treadmill at a speed of 1.0-3.0 km/h 5 minutes.