Effects of Lumbar Stabilization Exercise on the Strength, Range of Motion and Pain

Background: Few comparative studies have been conducted on strengthening the anterior and posterior muscles of the trunk via lumbar stabilization exercises.
Objectives: To compare the effects of forward leaning exercise and supine bridging exercise in stability exercise.
Design: Randomized controlled clinical trial (single blind).
Methods: Thirty subjects with spondylolisthesis were participated in this study. Fifteen subjects performed the bridging exercises and fifteen subjects performed the forward leaning exercises. Each exercise was held for ten seconds per repetition, and four repetitions were considered one sub-session. A total of four sub-sessions were performed in one full exercise session. The full exercise session required thirty minutes, including rest time. Trunk strength and range of motion and Oswestry disability index were measured.
Results: Two weeks later, trunk flexion strength and trunk extension range of motion were significantly increased in the forward leaning exercise group than in the supine bridging group, trunk extension strength were significantly increased in the supine bridging exercise group than in the forward leaning group. After two weeks, the pain score was significantly lower in the forward leaning exercise group than in the supine bridging group.
Conclusion: This study has shown that stabilization exercises are effective in increasing range of motion and strength in spondylolisthesis subjects. It was especially confirmed that the method of strengthening the anterior muscles of the trunk is more effective than the standard stabilization exercise method.

Keywords: *Spondylolisthesis; Stabilization exercise; Low back pain*

Chihwan Kim, PT, PhD[a], Sunghak Cho, PT, Prof., PhD[b]

[a]Department of Physical Therapy, Jaseng Hospital of Korean Medicine, Busan, Republic of Korea
[b]Department of Physical Therapy, Kaya University, Gimhae, Republic of Korea

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Address for correspondence
Sunghak Cho, Prof., PhD
Department of Physical Therapy, Kaya University, 208 Samgye-ro, Gimhae, Republic of Korea
Tel: 82-55-330-1054
E-mail: wow1300@hanmail.net

INTRODUCTION

In people with back pain, lumbar instability is a common symptom, and it can be classified into structural instability and functional instability. Structural lumbar instability can be described as a static instability in that abnormal frontal and posterior displacement is visible when radiographs are taken from the side of the vertebrae flexion or the end of the extension.[1] Functional lumbar instability can be defined as a dynamic instability due to loss of the ability to maintain normal spinal deformity when a normal, physiological load is applied to the lumbar.[2] If there is instability of the lumbar, excessively frequent movement occurs in the unstable segments when moving the limbs. As a result, physical stress builds up on the back tissues, causing minute damage and resulting in back pain.[3]

Spondylolisthesis is a representative disease with back instability symptoms referring to anterior displacement of the upper vertebrae to the lower vertebrae.[4,5] Structural instability leads to physiological instability, resulting in back pain and changes in lumbar lordosis.[6] Treatment can be divided into surgical and conservative categories. Most conservative treatments are attempted first, and surgical treatment is recommended if preservative treatment is not effective though conservative therapies are generally more effective than surgical treatments.[7-9]

Exercise is often performed as a conservative treatment to improve lumbar instability. In the past, many global muscle strengthening exercises through the movement of the body, such as sit-ups, were implemented.[10,11] However, in recent years, other lumbar stabilization exercises have been shown to be more effective.[12,13] Lumbar stabilization is a method of exercise aimed at appropriately controlling the local muscles responsible for back stability and the global muscles responsible for back movement.[14] For example, it is possible to strengthen the transverse abdominal muscles and multifidus muscles using the abdominal hollowing exercise for spondylolisthesis, and this lumbar stabilization exercise has a significant effect on decreasing back pain and improving function.[15]

The lumbar exercise method can be divided into exercises emphasizing the frontal muscles of the trunk or exercises emphasizing the back muscles. Some of these exercises are not based on stabilization. For example, the Williams lumbar flexion exercises emphasize the anterior muscles of the trunk,[10] while the McKenzie method emphasizes the back muscles of the trunk.[11] However, there are stabilization exercises such as the plank exercise which emphasize the anterior trunk muscles and others such as the bridging exercise that focus on the muscles behind the trunk.[16,17] Still other methods strengthen the trunk muscles in all directions, rather than isolating specific muscle groups.[18]

Previous research has studied the effect of stabilization exercise on the static state of spondylolisthesis patients,[15] while another comparative study considered the selective strengthening of the lumbar flexion and extension muscles without reference to stabilization exercises.[19] However, few comparative studies have been conducted on strengthening the anterior and posterior muscles of the trunk via lumbar stabilization exercises. To verify the differences between the objective effects of the exercise method, physical and clinical examinations, as well as physical function tests, were conducted in patients with lower back pain and spondylolisthesis.

SUBJECTS AND METHODS

Subjects

This was a randomized controlled trial. The experiment was explained thoroughly to the subjects, and they voluntarily agreed to participate in the study. This study targeted patients exhibiting lower back pain, with spondylolisthesis diagnosed in a hospital. In the sample, the anterior translation of the vertebral body was more than 4 mm, and the sagittal angle of the lumbar spine was more than 10°. Lumbar spine 5 sacrum 1 was selected as the sagittal plane angle of 12° or more (Figure 1). Exclusion conditions included: patients who were unable to lift from the waist down, those who could not lean their trunks forward, those with joint range of motion in the lower limbs, those with tumor and spinal cord injuries, and those with other neurological and orthopedic disorders that caused movement problems, such as infections. A total of 30 adult patients who were admitted to the B hospital participated in this study. A total of 30 subjects were divided into two groups of 15, according to the method of lumbar stabilization exercise used. The supine bridge exercise group and forward leaning exercise group were divided into two groups. The exercise group was randomly selected. The Ethics Committee and Institutional Review Board of Kaya University approved this study (kaya-196). Clinical Research Information System approved this study (KCT0003578).

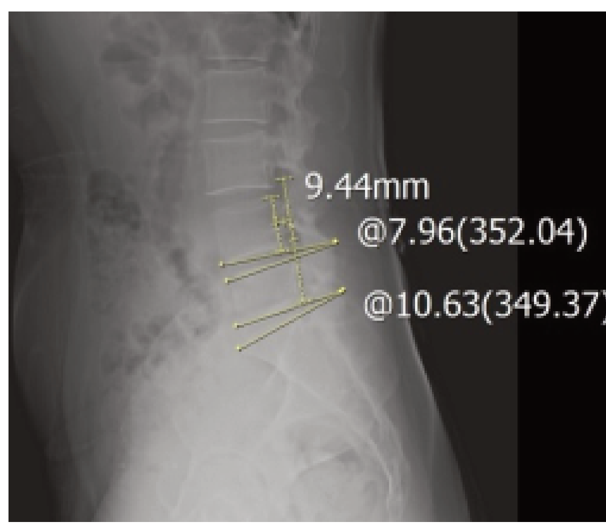

Figure 1. Spondylolisthesis subject selection criteria

Exercise methods

The bridging exercises and the forward leaning exercises were performed using a sling (Figure 2). The bridging exercises was performed with a strap on the ankle, and the forward leaning exercises was performed with a strap on the forearm in a painless range. Each exercise was held for ten seconds per repetition, and four repetitions were considered one sub-session. A total of four sub-sessions were performed in one full exercise session. After one set, a rest time was provided for 1 minute. The full exercise session required 30 minutes, including rest time. All exercises were conducted under one–to–one guidance from a physical therapist and were stopped at any time if the patients felt pain or discomfort. Exercise was performed three times a week for a total of two weeks.

Pain measurement

The korean version of the Oswestry disability index questionnaire was used in this study. It consists of nine questions, including the degree of pain, personal hygiene, lifting, walking, sitting, standing, sleeping, social life, and traveling. These questions are to be answered on a scale from zero to five points, depending on each participant's level of performance. The scores were calculated by substituting the official score / 45 * 100 with the disability index. The higher the score, the lower the level of functional performance due to back pain.[20]

Trunk strengthening measurement

We measured trunk strength using a dynamometer (Power dynamometer; JTeck medical, St. Paul, MN, USA). Trunk flexion muscle strength was measured to determine the maximum force without pain when performing trunk flexion in a supine position. To measure the trunk flexors strength, base of dynamometer was placed on the middle of the sternum and patient was instructed to exert isometric force by lifting both scapula off the plinth. Trunk extension muscle strength was measured to maximize pain without stretching when the trunk extension was performed in a prone posture (Figure 3). This method of measuring trunk muscle strength using a

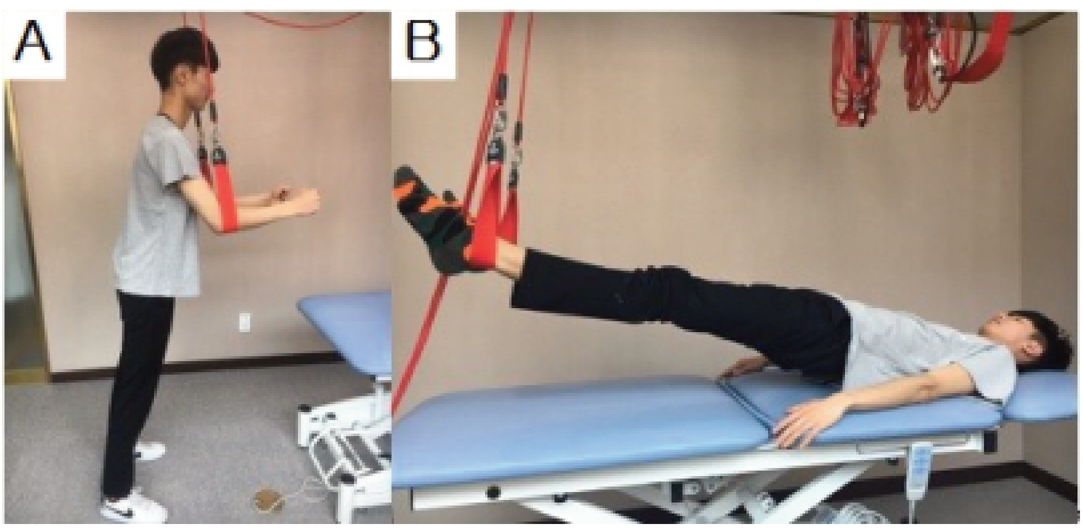

Figure 2. (A) Forward leaning exercise (B) Supine bridging

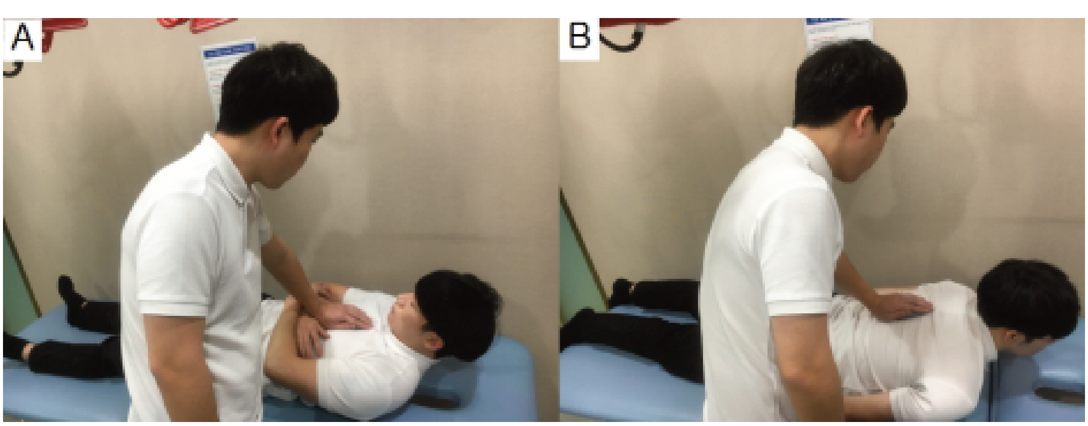

Figure 3. (A) Trunk flexion muscle strength (B) Trunk extension muscle strength

hand–held dynamometer showed an excellent intra–rater (.88–.98), comparable to the inter–rater value determined in a previous study (.84–.96).[21]

Trunk range of motion measurement

The measurement of the range of motion used a smartphone application called G–pro. The trunk flexion range of motion measured the slope of the trunk while the patient bent forward without pain in the stance. In addition, the trunk extension range of motion measured the slope of the trunk during back–ward descent without pain in the stance. Mark the spinous processes of the T1 vertebrae. Position incli–nometer over the spinous process of T1. At the end of the motion, read and record the values on inclinome–ters (Figure 4).[22]

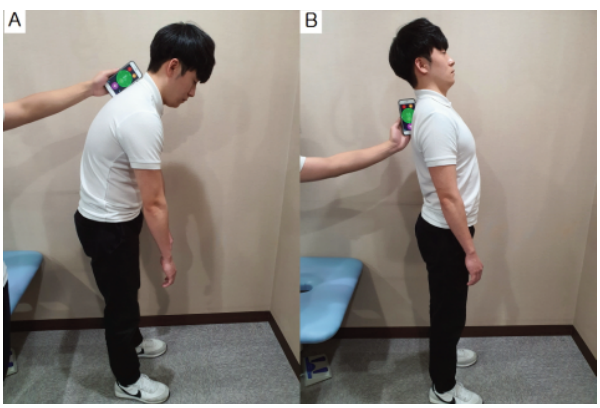

Figure 4. (A) Trunk flexion range of motion
(B) Trunk extension range of motion

Statistical analysis

The differences between the groups were compared via the Friedman test and, subsequently, by the Wilcoxon sign rank test. Differences between the two groups were compared using the Mann–Whitney test. The statistical program was SPSS 24.0 (IBM SPSS Inc., USA), and the significance level was set at .05.

RESULTS

General characteristics of the subjects

According to the exercise intervention method, we divided the subjects into two groups—one group of 15 patients attempting the supine bridging exercise and another group of 15 patients attempting forward leaning exercises. There were no statistically signifi–cant differences in age, height, and weight between the groups. The mean and standard deviation values are presented in the Table 1.

Table 1. Characteristics of subjects (n=30)

	FL (n=15)	SB (n=15)
Age (years)	57.5 ± 6.3	56.5 ± 8.2
Height (㎝)	159.8 ± 7.8	159.2 ± 7.7
Weights (㎏)	61.7 ± 6.8	61.0 ± 8.3

FL: Forward leaning, SB: Supine bridging

flexion strength

The trunk flexion strength was significantly differ–ent in the forward leaning exercise group, according to the intervention time in the same group. The results were significantly higher than two weeks before exercising and two weeks after exercising. In the supine bridging exercise group, there was no sig–nificant difference. The trunk flexion strength was no significant difference after intervention and after intervention. Two weeks later, significantly increased in the forward leaning exercise group, thereby indi–cating that trunk flexion strength had significantly increased as well. The mean and standard deviation values are presented in the Table 2.

extension strength

Trunk extension strength was significantly different in the supine bridging exercise group, according to the intervention time in the same group. The results were significantly higher than two weeks before exercising, and two weeks after exercising. In the forward leaning exercise group, there was no signifi–cant difference. The trunk extension strength was no significant difference after intervention and after intervention. Two weeks later, significantly increased in the supine bridging exercise group, thereby indi–cating that trunk extension strength had significantly increased as well. The mean and standard deviation values are presented in the Table 2.

flexion range of motion

The trunk flexion range of motion was significantly different in the forward leaning exercise group, according to the intervention time in the same group. The results were significantly higher than two weeks before exercising. The trunk flexion range of motion was also significantly different in the supine bridging exercise group, according to the intervention time in the same group, and results were significantly higher than two weeks before exercising and two weeks after exercising. There was no significant difference in the trunk flexion range of motion based on inter-group intervention time. The mean and standard deviation values are presented in the Table 2.

extension range of motion

The trunk extension range of motion was significantly different in the forward leaning exercise group, according to the intervention time in the same group. The results were significantly higher than two weeks before exercising and two weeks after exercising. In the supine bridging exercise group, there was no significant difference. The trunk extension range of motion no significant difference after intervention and after intervention. Two weeks later, significantly increased in the supine bridging exercise group. The mean and standard deviation values are presented in the Table 2.

Oswestry disability index

The results were significantly reduced in both the forward leaning exercise group and the supine bridging exercise group after two weeks compared to the measurements taken before the intervention. No significant difference before intervention, but, after two weeks, the pain score was significantly lower in the forward leaning exercise group than in the supine bridging group. The mean and standard deviation values are presented in the Table 3.

Table 2. Comparison of trunk strengthening, range of motion between forward leaning and supine bridging

		Pre	Post	2 weeks	χ^2	*P*
Flexion (N)	FL (n=15)	62.47 ± 7.09	64.20 ± 8.10	80.20 ± 5.48‡§	78.01	.01
	SB (n=15)	59.93 ± 8.46	60.00 ± 8.26	63.07 ± 10.17	3.97	.14
	z	-.69	-1.25	-4.34		
	P	.49	.21	.00*		
Extension (N)	FL (n=15)	29.67 ± 3.46	29.80 ± 4.93	30.60 ± 4.81	.52	.75
	SB (n=15)	30.53±5.36	32.60 ± 6.76	42.40 ± 8.12‡§	14.93	.01
	z	-.31	-1.33	-3.54		
	P	.75	.18	.00*		
Flexion ROM (°)	FL (n=15)	38.40 ± 8.28	39.47 ± 9.54	44.00 ± 8.71‡	12.31	.01
	SB (n=15)	39.80 ± 9.21	41.87 ± 8.25	52.00 ± 11.21‡§	16.10	.01
	z	-.23	-.71	-1.88		
	P	.82	.48	.06		
Extension ROM (°)	FL (n=15)	10.40 ± 5.78	12.47 ± 5.19	19.67 ± 3.39†‡	17.20	.01
	SB (n=15)	10.07 ± 3.61	10.33 ± 4.08	12.47 ± 4.22	4.13	.13
	z	-.27	-1.20	-3.75		
	P	.78	.23	.00*		

FL: Forward leaning, SB: Supine bridging
*$P<.05$ significant difference between Forward leaning and Supine bridging
†$P<.05$ significant difference between pre and 2 weeks
§$P<.05$ significant difference between post and 2 weeks

Table 3. Comparison of ODI between forward leaning and supine bridging

	Pre	2 weeks	Z	*P*
FL (n=15)	71.11 ± 10.00	55.26 ± 8.05	−3.41	.01†
SB (n=15)	71.26 ± 6.03	65.48 ± 7.55	−3.42	.01†
z	−.06	−2.94		
P	.95	.03*		

ODI: Oswestry disability index, FL: Forward leaning, SB: Supine bridging
**P*<.05 significant difference between Forward leaning and Supine bridging, †*P*<.05 significant difference between pre and 2 weeks

DISCUSSION

Stabilization exercises improved the back pain index, trunk muscle strength, and range of motion for spondylolisthesis subjects. Stabilization exercise is an effective method for subjects with lumbar instability and is widely practiced.[23,24] The stabilization exercises used in this study improved the patients' symptoms of spinal instability and strengthened their core muscles, such as the weakened transversus muscles and the multifidus muscles.[25,26] The cross-sectional area of the multifidus muscles is reduced in subjects with spondylolisthesis, and the erector spinae muscles have an increased cross-sectional area.[27] It is thought that the stabilization exercises used here activated the deep muscles, whose functions had been weakened, and the symptoms improved.

There was no significant difference between the forward leaning exercise and the supine bridging group before and after the exercise period. However, there was a significant difference of improvement in the measurements for both groups before the intervention when compared to two weeks. There was also a significant difference of improvement between measurements taken at two and at four weeks after the lumbar stabilization exercises. Therefore, it is thought that the effects of exercise are shown after elapsed time, rather than via immediate effects.[28]

There were differences in the muscle groups strengthened, according to the stabilization exercise method used. In previous studies, forward leaning exercises have shown that the activity of trunk flexors increases, and muscular strengthening occurs. Supine bridging exercises, on the other hand, increase the activity of the trunk extensors and result in muscle strengthening. These findings were corroborated in this study. Trunk flexion muscles were strengthened through the forward leaning exercises, while trunk extensor muscles were strengthened through the supine bridging exercises.[29,30]

There was a difference in the range of movement of the trunk according to the exercise method used. In the forward leaning exercises, the trunk extension range was increased, and the supine bridging exercises increased the trunk flexion range. Trunk flexion, in a standing posture, is controlled by the eccentric activation of trunk extensor muscles, and trunk extension is controlled by eccentric activation of trunk flexor muscles.[31] Forward leaning exercises are believed to have increased the trunk extension range due to strengthening the trunk flexor muscles. Supine bridging exercises are believed to have increased trunk flexion range due to strengthening the trunk extensor muscles.

Both groups showed improvement in pain two weeks after the stabilization exercises, but pain was further decreased by the forward leaning exercises. It is thought that these stabilizing exercises decreased pain by improving spinal instability. Particularly in the forward leaning exercises, the reason for pain improvement is thought to be the strengthening of the anterior muscles of the trunk and the prevention of increased lumbar lordosis. In spondylolisthesis subjects, an increase in lumbar lordosis may also increase the anterior displacement of the lumbar spine, which may worsen the symptoms.[32–34] Previous research has also illustrated that trunk flexion muscles strengthened lumbar lordosis and improved spondylolisthesis symptoms.[35,36]

This study has shown that stabilization exercises are effective intervention methods for spondylolisthesis subjects. It was especially confirmed that the method of strengthening the anterior muscles of the trunk is more effective than the standard stabilization exercise method.

The number of subjects, the length of the intervention period shortened to two weeks, and the change in the lumbar lordosis, which is considered an important variable, could not be compared before and after the intervention. These limitations should be improved, and future studies are necessary to further augment the findings of this research.

CONCLUSION

This study has shown that stabilization exercises are effective intervention methods for spondylolisthesis subjects. It was especially confirmed that the method of strengthening the anterior muscles of the trunk is more effective than the standard stabilization exercise method.

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