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The Effects of Sling Bridging Exercise to Pain Scale and Trunk Muscle Activity in Low Back Pain Patients

Most patients with chronic low back pain experience functional disability of trunk muscle, and limitations in physical activity. While there are many types of exercise programs available, in recent years sling exercise has been emerging as the exercise program for spinal stabilization. It has been supported by a great amount of research with positive findings on its effectiveness. This research studies the effects of bridging exercise, conducted on a sling, on pain level and trunk muscle activation in supine, sidelying, and prone positions during a 4 weeks period. 10 healthy people(normal group, n=10) and 28 patients with low back pain participated in this study. 28 patients were divided into two groups; one group participated in exercise with the sling(experimental group, n=14) and the other group exercised without the sling(control group, n=14). They were asked to use the Numerical Rating Scale(NRS) to answer to the level of their pain they felt (no pain: 0 point, severe pain: 10 points). During sling bridging exercises, the muscle activity level in each muscle measured in each position was standardized as three seconds of EMG signals during five seconds MVIC. In conclusion, the experimental group with four weeks of sling bridging exercise experienced a statistically significant reduction in the pain level($p<.05$) and increase in the muscle activities of erector spinae when in supine position, internal oblique when in sidelying position, and rectus abdominis in prone position($p<.05$). Regular sling bridging exercise reduces the low back pain and enhances other trunk muscle activation, thereby positively affect spinal stabilization.

Key words: *Sling Bridging Exercise; Trunk Muscle Activity; Low Back Pain*

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INTRODUCTION

As the sole species to walk erect, human beings became ridden with a condition called low back pain.

Low back pain is painful condition in the low back area caused by musculoskeletal abnormality, except for those resulting from pregnancy or infection. Patients with low back pain suffer from pain in the waist area, below the 10th thoracic vertebra for over three days(1, 2). Furthermore, low back pain refers to pain in the area of muscle behind the lumbar; this region of the muscle is controlled by dorsal rami of the lumbar nerve(3). Damage related to lumbar has been gradually increasing in westernized industrial societies(4).

Patients with chronic low back pain may experience difficulties in performing household and social activities, and in severe cases, basic daily activities. As a result, patients suffer from career limitations, economic difficulties and strained interpersonal relationships, ultimately leading to agony and distress over the inability to lead independent lives and poor perception of self-image(5).

Causes for low back pain is classified into two categories- organic and non-organic. Non-organic low back pain is a result of functional, emotional, psychological factors. These factors are caused by situations in daily life which induces tension or anxiety, or pre-existing problems in personality or emotion. Organic low back pain is caused by lesion in the spinal cord or its surrounding tissue, including the skeleton, muscles, pelvis and abdomen, etc. Such condition is caused by strenuous exercise, accidents, spinal diseases, aging, incorrect posture, and insufficient exercise. Of numerous causes, debilitation of soft tissue, not structural factors of the waist area, accounts for over 80% of all cases of low back pain(6).

When low back pain lasts for months, physical activities are constrained. The disuse of muscles leads to muscular atrophy, which in cases of chronic low back pain patients, results in decrease and muscular atrophy of the cross-sectional area of muscles surrounding the spinal cord, as well as reoccurrence and secondary damage(7).

In past treatment of low back pain, rest in bed and conservative physical therapy was commonly utilized. Since mid 1980s, the cause of low back pain was viewed as the lack of physical fitness, and the trend of the treatment has shifted towards active exercise programs, aiming to enhance physical fitness. Much of recent and active area of research has been providing proof that regardless of causes or effects of low back pain, enhancing the stability of the spinal cord is more effective to treatment and prevention of the condition(8).

Spinal stabilization exercise refers to enhancement of internal body function by improving physical balance through controlling big and small movements in conscious or unconscious state(9). It provides that the development of cognition, depending on muscle contraction and location of the spinal cord, leads to gradual progress from simple movements to more complex exercises(10). Based on the principles of motor learning, spinal stabilization exercise is frequently used to recover regulatory ability for muscle and movement, as well as to low back pain patients (11).

Among various spinal stabilization exercises, bridging exercise, which is a type of closed-chain weight bearing exercise, has been utilized in clinical trials in order to enhance muscular strength of hip extensors, namely gluteus maximus and hamstring muscle(12).

Research has provided that deep abdominal muscle training method can be additionally applied to bridging exercise in order to increase the activity level of deep muscles(13). Also, trunk stabilization exercise on an unstable support surface instead of a stable support surface is reported to further activate proprioception of more muscles and joints-ultimately inducing dynamic stability(14).

One of the devices that has therapeutic and workout effects in exercises conducted on an unstable support surface is the sling. The merits of sling exercise therapy in the field of physiotherapy is that it is especially effective in stabilization, neuromuscular control and muscle strengthening exercise, and in particular, closed-chain exercise. Extremely easy to use, it also contributes to spinal stabilization and provides therapeutic effect(15). Sling exercise therapy is a general concept for active exercises and treatments which use sling exercise devices, targeting continuous reduction of disorder in neuromuscular skeletal system(16).

Bridging exercise has already been widely utilized in clinical trials with various equipment and positions. A large number of studies have been conducted through diverse approaches and modifications. There has been extensive research and interest focused on changes in the activity level of trunk muscles, and many findings have been published. However, research on the effect of using slings during bridging exercise, one of the most commonly employed exercise programs, on the activity level of trunk muscles is insufficient. Therefore, by conducting four weeks of sling exercise program on patients with chronic low back pain, this research aims to study the resulting effect on the activity of trunk muscles and the degree of pain.

METHODS

Subjects

The subjects of this study were currently enrolled students and patients of University and Hospital (Seoul, South Korea) - a total of 38 participants. These 38 participants were divided into three groups: 10 people in the normal group, 14 people in the experimental group, and 14 people in the control group. The participants of the experimental group were patients of chronic low back pain, who received four weeks of sling bridge exercise in various positions. The control group consisted of patients of chronic low back pain who did not receive sling bridge exercise. The physical characteristics of the study participants are as showing Table 1.

Classification of Subjective Pain

In order to measure the level of subjective pain felt by patients before the sling bridging exercise, they were asked to use the Numerical Rating Scale(NRS) to answer to the level of their pain they felt(no pain: 0 point, severe pain: 10 points). Then, depending on the level of subjective pain, the patients were divided into four groups. In other words, the patients with mild pain were classified into Group I(pain level 0,1,2 points), moderate pain in Group II(pain level 3,4,5 points), severe pain in Group III(pain level 6,7,8 points), and intractable pain in Group IV(pain level 9,10). The subjects of this study were limited to Group I~III, and the pain level of the patients in these three chosen groups were measured in the same method after four weeks of exercise.

Table 1. The physical characteristics of the study participants (Mean±SD)

Group	Age(yrs)	Height(cm)	Weight(kg)
NG(n=10)	29.10±14.18	165.30±7.71	59.60±9.40
EG(n=14)	29.21±11.40	174.21±7.50	69.71±6.00
CG(n=14)	36.79±19.12	167.57±9.57	65.86±5.50

NG: Normal group, EG: Experimental group, CG: Control group

Experimental Device

In order to compare muscle activity level on a Suspension System(Redcord, Norway) attached to a fixed surface in each position(supine, sidelying, prone position; Fig. 1), the height of the sling was set at subject' s knee height. Hot packs(Silica-gel, A.C.C, USA) were used on all subjects for 20 minutes in order to evenly set their skin temperature at a constant level. After their skin was cleaned with alcohol swab, surface EMG pads were attached to the right side of the patients for the duration of sling bridge exercises, and muscle activity levels were measured. The raw surface EMG signals were band pass-filtered between 10 and 500㎐ and amplified using a differential amplifier(MyoSystem 1,400, Noraxon Inc, Scottsdale, AZ). The signals were analogue/digitally(A/D)(12-bit resolution) converted at 1,000㎐ and stored in a lap top computer(17).

Experimental Procedure

The researcher thoroughly explained the purpose of the experiment and its significance. Subjects were asked to use the NRS to answer to the level of their pain they felt(no pain: 0 point, severe pain: 10 points). Then, to examine the activity level of trunk muscles in each body position, the area where surface EMG electrodes were to be attached was marked, then the surface electrodes were attached. EMG signals for a total of four muscles(Rectus abdominis, external oblique, internal oblique, and erector spinae) were simultaneously collected.

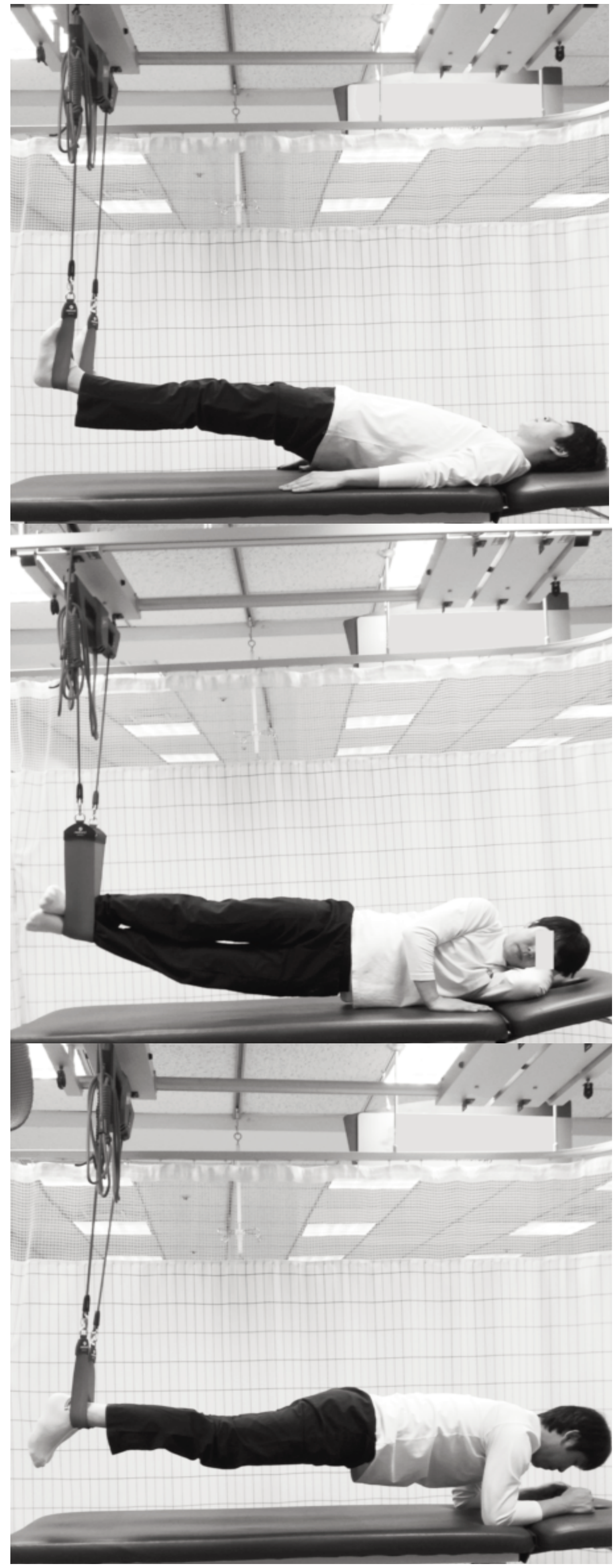

Fig. 1. Position of sling bridging exercise
A. Supine position, B. Sidelying position, C. Prone position

The electrode for rectus abdominis was attached 3 ㎝ outwards from the umbilicus, on the midline, parallel to the direction of muscle fiber. For external oblique, the electrode was attached at a point 15㎝ outwards from the umbilicus, parallel to the direction of muscle fiber. Internal oblique electrode was attached at a point 10㎝ outwards from the midline, 2㎝ below the ASIS, and in the direction from outer-below to inner-above. The electrode for erector spinae was attached at 2㎝ outwards from L_4-L_5 interspinous process. Finally, the ground electrode was placed above the 11th rib(18).

Before the measurement, the subjects were trained in the basic movements of each position. They repeated the positions three times while keeping their posture with straightened trunk muscles. At the preparatory command of 'Ready', the subjects assumed the posture. At each position, EMG activity level was measured for five seconds during Maximal Voluntary Isometric Contraction(MVIC). For the next four weeks, twice a week, change in muscle activity level was measured after three sets, with one set consisting of undergoing 10 times of each position. During sling bridging exercises, the muscle activity in each muscle measured in each position was standardized as three seconds of EMG signals during five seconds MVIC.

The saved data were full-wave rectified and smoothed with a root mean square(RMS) with a window of 150 milliseconds. For each of the muscles and for each testing session, the RMS was calculated for the 3 repetitions of the different exercises. Noraxon MyoResearch software 2.10 was used(17).

Data Analysis

Paired t-test was used to find the average and standard deviation of each measured item, as well as the difference between the before and after of the study among the groups for each position. In addition, two-way ANOVA was used to analyze the difference among the groups in each position for change variation in trunk muscle activity level. For statistical processing of the data, Statistical Package for the Social Science(SPSS), Windows version 12.0 was utilized. Significancelevel was set to α=.05

RESULTS

Changes of Subjective Pain

The comparative analysis of subjective pain level using the NRS before and after the experiment in the normal group, experimental group, and control group are as shown below in Table 2. While the pain level of the normal group increased from 1.8±0.6 to

Table 2. Change of NRS intervention (Mean±SD)

Group	Pre	Post	t	p
NG	1.8±0.6	2.1±0.7	-1.000	.343
EG	5.8±0.7	3.1±0.6	21.6333	.000**
CG	5.4±0.7	5.6±0.5	-1.000	.336

** p ＜ .01

NG: Normal group, EG: Experimental group, CG: Control group

Table 3. Change of trunk muscle activation for each group after intervention in supine position (Mean±SD)

Group	Muscle	Pre	Post	t	p
NG	RA	24.83±36.26	28.23±65.94	-.134	.897
	IO	22.41±30.02	33.81±34.15	-.715	.493
	EO	23.09±21.60	25.53±16.32	-.298	.772
	ES	59.27±54.10	70.30±34.33	-.808	.440
EG	RA	31.01±35.16	26.64±56.03	.225	.826
	IO	21.04±26.46	69.76±89.48	-2.149	.051
	EO	21.40±27.70	15.94±20.84	.541	.598
	ES	55.14±41.91	94.82±48.73	-3.428	.004 **
CG	RA	17.74±21.93	13.04±28.19	.688	.503
	IO	18.54±25.10	21.61±25.69	-.291	.775
	EO	18.54±25.10	14.45±9.85	.565	.582
	ES	83.10±40.21	53.84±30.83	2.662	.020 *

* p ＜ .05, ** p ＜ .01

NG: Normal group, EG: Experimental group, CG: Control group

RA: Rectus abdominis, IO: Internal oblique, EO: External oblique, ES: Erector spinae

2.1±0.7 in four weeks, it had no statistical significance. The experimental group, which received sling bridging exercise, showed a statistical significance ($p<.05$) in the decrease of subjective pain level from 5.8±0.7 to 3.1±0.6 after 4 weeks. On the other hand, the pain level of control group had slightly increased from 5.4±0.7 to 5.6±0.5 in 4 weeks, but was found to be statistically insignificant.

Table 4. Change of trunk muscle activation for each group after intervention in sidelying position (Mean±SD)

Group	Muscle	Pre	Post	t	p
NG	RA	52.59±54.12	47.39±73.58	.431	.677
	IO	73.48±72.53	59.38±32.59	-.817	.435
	EO	59.38±32.59	59.92±10.60	-.031	.976
	ES	45.40±35.53	56.28±38.13	-.739	.479
EG	RA	53.84±48.33	97.60±140.22	-1.197	.253
	IO	43.76±46.89	136.20±84.98	-4.964	.000 **
	EO	75.72±53.49	54.82±54.94	.958	.356
	ES	48.63±34.84	45.87±32.39	.202	.843
CG	RA	39.74±36.98	3324±34.39	.818	.428
	IO	71.28±53.41	43.09±29.70	1.520	.152
	EO	50.60±48.40	51.31±49.62	-.032	.975
	ES	57.00±61.89	53.05±42.41	.198	.846

** $p<.01$
NG: Normal group, EG: Experimental group, CG: Control group
RA: Rectus abdominis, IO: Internal oblique, EO: External oblique, ES: Erector spinae

The research outcome showed that for the normal group and control group, there was a slight increase in pain level. Furthermore, it showed with statistical significance($p<.05$) that the reduction of low back pain was greater in experimental group with sling bridging exercise than in control group that did not receive any exercise.

Comparison of Trunk Muscle Activity

In supine position, the activity of erector spinae muscle in the experimental group increased with statistical significance($p<.05$). In the control group, the activity of erector spinae muscle decreased with statistical significance($p<.05$).

Table 5. Change of trunk muscle activation for each group after intervention in prone position (Mean±SD)

Group	Muscle	Pre	Post	t	p
NG	RA	88.86±88.45	96.12±74.42	-.460	.656
	IO	100.51±110.04	98.06±73.91	.055	.957
	EO	81.11±36.50	36.51±55.31	2.799	.021 *
	ES	32.04±30.04	44.96±53.50	-.780	.455
EG	RA	79.09±74.86	171.41±128.04	-3.258	.006**
	IO	81.26±96.66	111.44±82.81	-.843	.414
	EO	64.99±61.33	63.43±111.73	.075	.942
	ES	28.40±40.68	54.41±55.19	-1.505	.156
CG	RA	96.20±103.03	72.72±56.06	-825	.424
	IO	42.34±34.50	38.12±32.46	.349	.733
	EO	53.90±71.17	34.95±37.68	.833	.420
	ES	39.36±50.23	19.51±22.63	1.678	.117

* $p<.05$, ** $p<.01$
NG: Normal group, EG: Experimental group, CG: Control group
RA: Rectus abdominis, IO: Internal oblique, EO: External oblique, ES: Erector spinae

Table 6. Post-hoc in trunk muscle activity between position and group (Mean±SD)

Source	Dependent variable	Type III SS	df	F	p	post-hoc
Position	RA	17692.142	2	1.215	.301	ns
	IO	7191.123	2	.512	.601	
	EO	5483.874	2	.662	.518	
	ES	879.043	2	.154	.857	
Group	RA	68530.730	2	4.706	.011 *	CG $<$ EG
	IO	99025.302	2	7.050	.001 **	CG $<$ EG
	EO	741.369	2	.090	.914	ns
	ES	33600.042	2	5.885	.004 **	CG $<$ EG

* $p < .05$, ** $p < .01$

NG: Normal group, EG: Experimental group, CG: Control group

RA: Rectus abdominis, IO: Internal oblique, EO: External oblique, ES: Erector spinae

ns: no significant

Other cases had no statistically significant changes (Table 3).

In Sidelying Position, the activity of internal oblique muscle in the experimental group increased with statistical significance($p<.05$). Other cases had no statistically significant changes(Table 4).

In Prone Position, the activity of rectus abdominis muscle increased in the experimental group with statistical significance($p<.05$). In the normal group, the activity of external oblique muscle decreased with statistical significance($p<.05$). Other cases had no statistically significant changes(Table 5).

Differences of Trunk Muscle Activity in Each Position and Group

The degree of change in trunk muscle activity for each body position before and after the experiment had no statistically significant differences. In comparison of the groups, rectus abdominis muscle ($p<.05$), internal oblique muscle($p<.05$), erector spinae muscle($p<.05$) showed statistically significant changes; post-hoc showed that there was a difference between the experimental and the control group. For external oblique muscle, there was no statistically significant changes(Table 6).

DISCUSSION

The purpose of this research is to study the effect of the sling, integrated with spinal stabilization exercise and the latest theories on exercise therapy, on the pain reduction and trunk muscle activity in patients of chronic low back pain. With these results, it aims to provide an effective exercise program to the patients. Chronic low back pain is a condition that limits one's daily activities. Among chronic illnesses aside from cardiovascular disorders, it is one of the biggest causes of frequent hospital visits(19). Patients with chronic low back pain suffer from lumbar mobility limitation, which leads to a decrease in flexibility and weakening of muscular strength and endurance.

To a patient of chronic low back pain, regular exercise improves motor control ability by strengthening ligament, bone, tendon, and muscle, and providing sufficient nourishment to various joints and cartilage, including the spinal disc(20). Furthermore, regular exercise increases low back muscle strength and endurance, leading to reduction of low back pain and enhancement of the functional aspect(21). There are greater proof of the effectiveness of spinal stabilization exercise over ordinary fitness exercise program, with research stating that spinal stabilization exercise must be prescribed for rehabilitation exercise programs(22, 23).

Other researches show that when motor control therapy was implemented on patients with chronic lumbar pain for eight weeks, the pain level decreased by 2.7 points, compared to the pain level before the exercise programs began(24). In comparative research of motor control therapy group versus drug treatment group for a period of 4 weeks and one-year after the beginning of research, the results showed that the group with motor control therapy began to experience decreased pain from the 4 week(25). In another program conducted for 8 weeks with patients of chronic low back pain, one group provided with spinal stabilization exercise and another provided with sling exercise both experienced level of impaired function had decreased by 6.6 points and 6.1 points, respectively(26). Also, a group that underwent specific stabilization exercise for 12-weeks experienced a greater decrease in pain level by 2.4 points than the other group that received no exercise(27).

This aforementioned result concurs with the finding of this study at hand, as there was also a 2.7 points decrease in pain level in the group of chronic low back pain patients who received 4 weeks of sling exercise. In terms of pain relief, the normal group that did not go through sling exercise had only been experiencing slight pain that was nearly imperceptive before the 4 weeks experiment began, and this did not change after the 4 weeks. In the control group that did not receive sling exercise, there was no change in the pain level. On the other hand, the experimental group which received 4 weeks of sling exercise experienced noticeable and statistically significant reduction in the pain level; the pain level of the participants of the experimental group was nearing the pain level of the normal group.

This proves the effectiveness of sling exercise on pain relief for chronic low back pain patients with moderate pain. The research by Stevens and Imai shows that bridging exercise on a stable support surface had no effect on the proportion of erector spinae muscle in trunk muscles activity(28, 29). The findings of this research is able to confirm that erector spinae muscle is activated at a relatively greater proportion in all groups, when the exercise is conducted in supine position.

While another research has stated that there was no relevant difference between the muscle activity level in rectus abdominis and external oblique during bridging exercise of chronic low back pain patient, this research shows that the RMS level has increased overall, but statistical significance was observed for only the experimental group. The results show that in supine position, the RMS level increased for erector spinae; in sidelying position, RMS increased for internal oblique; in prone position, RMS increased for rectus abdominis. However, findings also indicate that when bridging exercise is conducted in supine position, muscle activity levels in rectus abdominis and external oblique are low, concurring with the aforementioned research. This confirms that correct and regular bridging exercises at each position enables the suppression of muscles that were irregularly used, as well as the utilization of particular muscles. Moreover, the findings also show that aside from the muscles that have shown statistical significance in muscle activity at each position in the experimental group, the exercise enhances the overall muscle activity level to become close to that of the normal group. It also contributes to spinal stabilization, and ultimately to mitigation of low back pain.

Jenkins remarked that active exercise therapy program for low back pain normalizes physical functioning, and decreases pain(30). Akuthota stated that while spinal stabilization exercise is also referred to as many various names, such as core strengthening, dynamic stabilization, trunk stabilization, muscular fusion, neutral spine control, etc, they all share a single aim to enhance the functional stability in the areas around the abdomen and pelvis. It is most effective when the various functions of different muscles are clearly understood, and proper exercise programs are applied to match the muscular characteristics(31).

It is further stated that neuromuscular activation rehabilitation exercise recovers the function of stabilizer and abdominal muscle, which aids postural stability of trunk muscles, and increases and strengthens the muscles in damaged parts(12). In conclusion, while this research needed more time in order to completely relieve low back pain, during the 4 weeks it was able to confirm the significant effect that exercise conducted on the sling has on pain relief and muscle activity level at various positions, as well as the role of trunk muscle as an agonist muscle at various positions.

CONCLUSION

This research aims examine the effect of sling bridging exercise program, conducted in various positions, on the pain and muscle activity in patients of chronic low back pain. In order to achieve the purpose of this study, an analysis was done to compare the experimental group, which underwent the sling bridging exercise program, versus the control group and the normal group both of which did not take part in the exercise program.

The study arrived at the following conclusion:

There was no change in the pain level of the normal group and the control group, both of which did not receive sling bridging exercise. On the other hand, the experimental group that participated in sling bridge exercise experienced a statistically significant reduction in the pain level($p<.05$).

The experimental group with four weeks of sling bridge exercise experienced a statistically significant($p<.05$) increase in the muscle activities of erector spinae when in supine position, internal oblique when in sidelying position, and rectus abdominis in prone position.

There was no statistically significant change in muscle activity for each type of position, when the trunk muscle activity among the groups from before the experiment and after were compared. However, when the groups were compared, statistically significant change($p<.05$) was observed in rectus abdominis, internal oblique, and erector spinae.

In sum, 4 weeks of regular sling bridging exercise reduces the pain of low back pain patient, and increases activity of muscles. It especially increases muscle activity level in each position, and enables the use of correct muscles. In addition, sling bridging exercise enhances other trunk muscle activation, thereby positively affect spinal stabilization.

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