

# Effects of Sling Bridge Exercise with Rhythmic Stabilization Technique on Trunk Muscle Endurance and Flexibility in Adolescents with Low Back Pain

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## ABSTRACT

The purpose of this study was to examine the effects of general sling-bridge exercise (GSE) and sling-bridge exercise with rhythmic stabilization technique (SER) on trunk muscle endurance and flexibility in adolescents with low back pain (LBP). 30 adolescents who had complaints of LBP were randomly assigned to one of the two groups: the GSE group (n=15) and SER group (n=15). Subjects performed each exercise programs for 4 weeks with the aim of improving trunk muscle stability; GSE group trained general bridge exercise with sling, SER group trained rhythmic stabilization bridge exercise with sling. The static and dynamic trunk muscle endurance and flexibility were measured before and at the end of the exercise program. The static and dynamic trunk muscle endurance were significantly improved in both groups ( $p < .05$ ) and the SER group showed significant difference from the GSE group after the exercise ( $p < .05$ ). The trunk muscle flexibility was significantly improved in both groups ( $p < .05$ ) and the SER group were significantly different from GSE group post-exercise ( $p < .05$ ). The results of this study showed that sling bridge exercise with rhythmic stabilization technique may be appropriate for improving trunk muscle stability in adolescents with LBP.

**Key words:** Low Back Pain, Sling-Bridge Exercise, Rhythmic Stabilization Exercise, Muscle Endurance, Flexibility.

## 1. INTRODUCTION

Low back pain (LBP) is a major public health problem regarding its medical and economic impact worldwide [1], [2]. While the lifetime prevalence of LBP is reported to be up to 84%, little scientific evidence is available for the prevalence of disabling chronic LBP [3]. Especially, the prevalence of LBP in adolescents has been increased in recent times [4]. Malleson and Clinch [5] reported that LBP in adolescents was considered unusual and often a harbinger of serious organic disease. According to the literature, LBP in adolescent is associated with LBP in the future [6]. Several studies have shown that LBP may limit daily activities in 10% to 40% of adolescents [7], [8]. The high prevalence of LBP in adolescents and the predictive value that LBP in adolescents has on suffering LBP

as an adult have led to preventive and therapeutic physical therapy treatment [9] for LBP being carried out in the adolescent stage [10].

Although there are few known effective treatment options for patients with LBP, exercise is one of the most frequently used modalities for the LBP [11]. Freburger et al. [12] reported that trunk muscle exercise is prescribed to approximately 50% of all patients with LBP seeing a physician and a physical therapist. Especially, the stabilization exercise interventions have been successful at treating LBP [13]. Susan et al. [14] proposed that trunk muscle exercise intervention for LBP should focus on the best method to target the stabilizing musculature during specific exercises.

Sling exercise is performed while the pelvis or lower extremities are supported or suspended in a sling. The patient must bear weight through the cords and balance themselves during the sling exercise. According to the Ljunggren et al. [15], sling exercise has been proposed to activate local spine stabilizers during the activity in a pain free manner without

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substitution of global muscles. Both strength and muscle coordination were needed to maintain the neutral spine position [16]. Proprioceptive neuromuscular facilitation (PNF) exercises are designed to promote the neuromuscular response of the proprioceptors. PNF is utilized to restore flexibility and increase strength by increasing the length of the muscle and increasing neuromuscular efficiency in patients who have sustained soft tissue damage or received invasive surgeries [17]. PNF has also been found to increase muscular performance when performed in regarding exercise [18]. Nelson et al. [19] found PNF to be even more beneficial than strength training in increasing strength and athletic performance for untrained individuals over an 8 week period; muscle power, strength and ROM increased during the protocol. The rhythmic stabilization (RS) is an isometric contraction of the agonist pattern followed by the antagonist pattern. The technique is performed without relaxation using careful grading of resistance. Indications for RS include instability in weight bearing and holding and poor static postural control [20].

The primary goals of exercise in the management of LBP are to improved muscle strength, flexibility and endurance, to restore injured tissue, and to contribute to the ability to sustain normal life activities [21]. In recent years treatments have been administered to adolescents for LBP, but it is not known which physical therapy treatment is most efficacious. Furthermore, the effects of sling-bridge exercise with PNF technique on trunk muscle endurance and flexibility are unclear. The purpose of this study was to examine the effects of general sling-bridge exercise (GSE) and sling-bridge exercise with rhythmic stabilization technique (SER) on static and dynamic trunk muscle endurance and flexibility in adolescents with LBP.

## 2. SUBJECTS AND METHODS

### 2.1 Experimental design

The experimental design of this study was a randomized controlled trial design. A randomized controlled trial was performed with subjects randomly assigned to one of the two treatment groups: (1) a group that received general sling-bridge exercise (GSE; n=15) or (2) a group that received sling-bridge exercise with rhythmic stabilization technique (SER; n=15). The training groups were assigned to their respective programs for a period of 4 weeks. Subjects were not aware of the theoretical bases of each of the exercise. The static and dynamic trunk muscle endurance and flexibility were measured before and at the end of the exercise program.

### 2.2 Subjects

Thirty adolescents aged 13-19 with a current episode of LBP were recruited to participate in this study. Subjects were eligible for the study if they had a history of recurrent LBP (repeated episodes of pain in past year collectively lasting for less than 6 months) of a nonspecific nature, defined as back pain complaints occurring without identifiable specific anatomical or neurophysiological causative factors [22]. None of the subjects received additional physical therapy interventions during the study period.

Table 1. Characteristics of 2 subject groups

Group	Characteristic		
	Age(yrs)	Height(cm)	Weight(kg)
GSE (n=15)	15.33±1.40	169.73±4.02	65.47±3.40
SER (n=15)	15.73±1.44	170.47±4.62	69.27±5.18

### 2.3 Training programs

The two experimental groups (GSE, SER) participated in four weeks program that aimed to improve trunk muscle stability. The training frequency for both groups was five times per week and the training volume per session include three sets of 15 repetitions. Common components of the two groups included a conventional physical therapy (hot pack 10 min, TENS 15 min) and standardized warm-up exercise (stretching exercise 10 min).

**2.3.1 General sling-bridge exercise (GSE):** The Terapi Master sling exercise therapy device (Nordisk Terapi Master, Norway) was used for GSE. The subjects began by laying supine on the treatment table with their hips and knees bent to 90 degrees. The subject's knees were placed in a sling that was suspended from the ceiling. The subjects lift their hip into the air while maintaining straight alignment of the knees, hips and shoulders. The subjects held this position for five seconds and then lowered back to the starting position [14] [Fig. 1].



Fig. 1. General sling-bridge exercise

**2.3.2 Sling-bridge exercise with rhythmic stabilization (SER):** The subjects were held the bridge position in a sling while the therapist applied rotational resistance to the pelvis. The physical therapist's one hand is placed on the posterior pelvis on one side, pulling up at the hip while the other hand is on the opposite side, pushing down on the anterior pelvis [23]. The SER program consisted of alternating isometric contractions against resistance for 10 second, with no motion intended [24] [Fig. 2]. Given the maximal resistance provided each time by the physical therapist, but subjects were not twisted in any direction.



Fig. 2. Sling-bridge exercise with rhythmic stabilization

## 2.4 Outcome assessment

All outcomes (static and dynamic trunk flexor endurance and static and dynamic trunk extensor endurance and flexibility) were measured by a trained physical therapist before and at the end of the exercise program. To prevent fatigue from having a significant impact on scores, the tests that required minimal effort were performed first, and the most strenuous tests were performed last.

**2.4.1 Trunk flexion endurance:** Trunk flexion endurance was assessed using the curl-up test [20]. The subjects lay supine with the knees at an angle of 90 degrees (feet fixed by strap) and with arms straight at the sides of the body and pointing toward their knees. To measure the dynamic endurance, subjects performed as many consecutive curl-ups as possible at a rate of 25 per minute to a maximum of 25. The number of repetitions performed was recorded. To measure the static endurance, subjects were instructed to curl up with straight arms pointing toward their knee until their iliac crests were raised from the table and to hold this posture for a maximum of 240 seconds. The time of maintaining the position was recorded. The test was terminated if the subjects showed any sign of exhaustion, pain or reduction in the range of motion.

**2.4.2 Trunk extension endurance:** Trunk extension endurance was assessed using the modification of the Biering-Sørensen test [25]. The subjects lay prone on the table with the upper edge of the iliac crests aligned with the table and the lower extremity fixed to the table with strap. To measure the dynamic endurance, subjects performed as many consecutive trunk extensions as possible at a rate of 25 per minute to a maximum of 25. The number of repetitions performed was recorded. To measure the static endurance, subjects were instructed to trunk extension with maintained a horizontal position as long as possible for maximum of 240 seconds with no rotation or lateral shifting. The length of time holding the upper trunk horizontally was recorded. The test was terminated if the subjects showed any sign of exhaustion, pain or reduction in the range of motion or upper trunk dropped below the horizontal.

**2.4.3 Trunk flexibility:** Trunk flexibility was assessed using the Fingertip-to-Floor Test [26]. The test was used to examine the subjects' ability to bend forward. The subjects standing on a stool with the feet 10 cm apart, were asked to bend forward with straight knees and try to touch the floor with the fingertips. The distances between middle fingertips, stool seat and below stool level were recorded in centimeters. Lower scores are associated with increased trunk flexion flexibility.

## 2.5 Statistical method

For the statistical analysis of this study, SPSS 12.0 ver. for window<sup>®</sup> was used. The results of all experiments were expressed as a mean and standard deviation. Independent t-test was used for the comparison between a GSE group and a SER group. The changes of muscle endurance values in accordance with the lapse of time were analyzed for the comparative verification pre and post-exercise programs in each group using paired t-test was used. Statistical significance was recognized

with the p value less than 0.05.

## 3. RESULTS

### 3.1 Changes of trunk flexion endurance

The value of static trunk flexion endurance for the GSE group was  $52.13 \pm 3.56$  before the exercise, but it was increased to  $63.6 \pm 3.78$  four weeks later. The value of static trunk flexion endurance for the SER group before exercise was also increased from  $49.8 \pm 12.2$  to  $69.47 \pm 5.32$  after four weeks. Both groups showed significant difference between pre and post-exercise periods ( $p < .05$ ), and the SER group was significantly different from GSE group at the same period. ( $p < .05$ ) (Fig. 3).

Dynamic trunk flexion endurance showed similar increases before and after exercise for both groups, from  $8.4 \pm 1.30$  and  $8.33 \pm 2.29$  to  $9.93 \pm 1.16$  and  $12 \pm 1.13$  for the GSE and SER groups, respectively. Although both groups showed significant difference between pre and post-exercise ( $p < .05$ ), the SER group showed more significance than the GSE group ( $p < .05$ ) [Fig. 3].

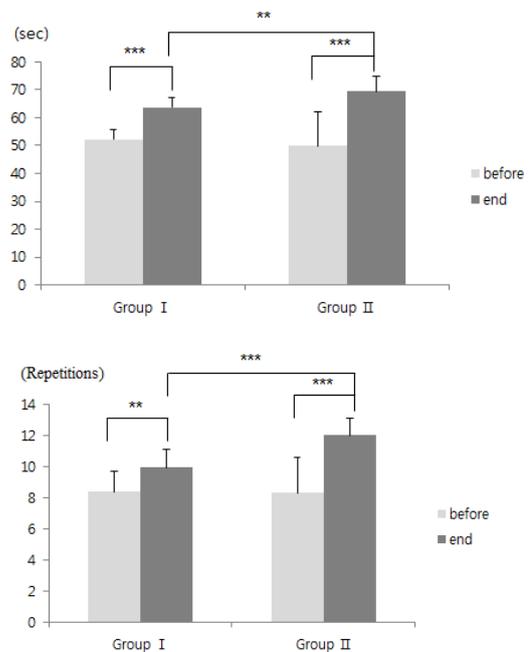


Fig. 3. Static(sec) and dynamic(repetitions) endurance of the trunk flexors in each groups

All values showed mean±SD

Group I : GSE                      Group II : SER

Tested by paired t-test and independent t-test

\*:  $p < .05$ , \*\*:  $p < .01$ , \*\*\*:  $p < .001$

### 3.2 Changes of trunk extension endurance

After four weeks, the value of static trunk extension endurance for the GSE group was increased from  $74.67 \pm 5.61$  to  $102.13 \pm 29.07$ , while that of the SER group increased from  $74.2 \pm 4.3$  to  $140.6 \pm 13.6$ . Both groups showed significant difference before and after the exercise ( $p < .05$ ). Especially, the difference was more significant in the SER group than the GSE group after the exercise ( $p < .05$ ) [Fig. 4].

There was a significant increase in the values of dynamic trunk extension endurance after four weeks' exercise for the GSE group and the SER group, from  $8.33 \pm 1.59$  to  $10.87 \pm 1.06$  and from  $8.8 \pm 1.57$  to  $15.4 \pm 2.5$ , respectively ( $p < .05$ ). However, the SER group showed more significance than the GSE group ( $p < .05$ ) [Fig. 4].

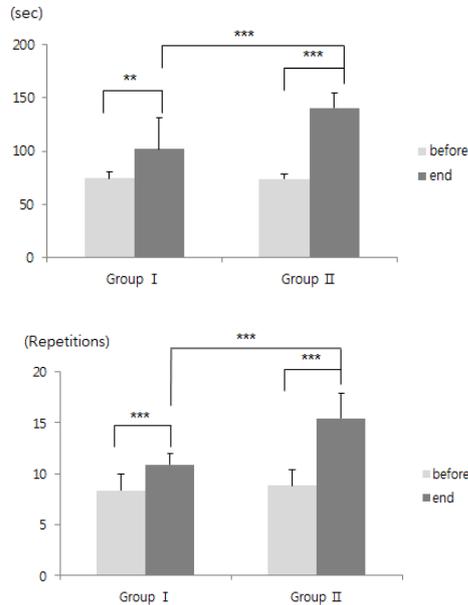


Fig. 4. Static(sec) and dynamic(repetitions) endurance of the trunk extensors in each groups

All values showed mean±SD

Group I : GSE                      Group II : SER

Tested by paired t-test and independent t-test

\*:  $p < .05$ , \*\*:  $p < .01$ , \*\*\*:  $p < .001$

### 3.3 Changes of trunk flexibility

The value of trunk flexibility for the GSE group was  $6.13 \pm 1.51$  before the exercise, but it was increased to  $4.13 \pm 1.3$  4 weeks after. The value of trunk flexibility for the SER group was  $6.6 \pm 1.45$  before the exercise, but it was increased to  $2.13 \pm 0.74$  4 weeks after. Both groups showed significant difference between before and after the exercise ( $p < .05$ ). SER group showed significant difference from GSE group after the exercise ( $p < .05$ ) [Fig. 5].

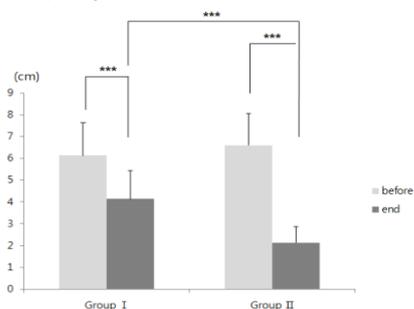


Fig. 5. The changes of trunk flexibility in each groups

All values showed mean±SD

Group I : GSE                      Group II : SER

Tested by paired t-test and independent t-test

\*:  $p < .05$ , \*\*:  $p < .01$ , \*\*\*:  $p < .001$

## 4. DISCUSSION

This study compared the effects of sling-bridge exercise with rhythmic stabilization technique and general sling-bridge exercise on trunk muscle endurance and flexibility for adolescents with LBP. The main findings of this study are that SER program is effective in treating adolescent with LBP, when compared to GSE program. Subjects allocated to the SER group showed significant improvement in trunk muscle endurance and flexibility in comparison to the SER group.

The goal of rehabilitation programs for patients with LBP is often based on an ability to regain neuromuscular control of trunk muscle, in conjunction with other segmental stabilizers [14]. According to Panjabi [27], all patients with LBP may benefit from spinal stabilization exercise retraining on the premise that deconditioning of trunk muscle leads to instability symptoms. However, there is often recurrence to LBP that has been illustrated in several studies [15], [28]. Sling exercise is the recommended plan for stabilization classification of LBP patients. Especially, sling-bridge exercise used in this study addressed the ability to stabilize the lumbar spine while moving the lower extremities with unstable support.

People with LBP often demonstrate reduced muscle strength and endurance levels, and altered flexibility accompanied by low-intensity pain levels and reduced functional ability [11]. Therefore, this study assessed trunk muscle (flexor and extensor) endurance (static and dynamic) and trunk flexibility by curl-up test, Biering-Sørensen test and Fingertip-to-Floor Test before and at the end of the exercise program. According to Bierining-Sorensen [29], trunk muscle endurance has been identified as a potential risk factor for the development of back pain. In this study, trunk muscle endurance significantly increased after both GSE and SER programs [Fig. 3, 4]. This finding could be attributed to the fact that spinal stabilization exercise using sling involves muscle work at significant intensity levels that result in muscle endurance improvements. Our results are similar to the study by Saliba et al. [14] in that the sling-bridge exercise when combined with dynamic movement resulted in a significant higher activation of the local stabilizers of the spine compared with traditional bridging exercise. Women with pelvic girdle pain after pregnancy showed significantly lower pain and improved function after 20 weeks with a specific exercise program with sling relative to ordinary physical therapy, and Stuge et al. [30] proposed that increased activation of local stabilizer muscles with the sling exercise therapy may have contributed to improved outcomes in comparison to traditional therapy.

To the trunk flexion flexibility measurement, this study used Fingertip-to-Floor Test. Intraclass correlation coefficients for test-retest reliability have been reported as satisfactory, but variability was high [31]. In this study, trunk flexibility increased after both GSE and SER programs [Fig. 5]. This finding could be attributed to the fact that exercises take advantage of the body's inhibitory reflexes to improve muscle relaxation. This muscle relaxation allows a greater stretch magnitude during stretch training, which should result in superior gains in flexibility. Our results are different from the study by Unsgaard-Tøndel et al. [16] demonstrating no

evidence that treatments with individually instructed motor control exercise or sling exercise were superior to general exercises for chronic low back pain. The reasons for these differences may be related to the exercise intensity and intervention duration. Exercise intensity was progressively increased and adjusted to each subject's performance, so, significant muscle system adaptations were observed at the end of each exercise program [32].

Although muscle endurance and flexibility measurements were significantly improved for both exercise groups, SER group was significantly different from GSE group after the exercise [Fig. 3, 4, 5]. This finding could be attributed to the specific of the SER program, which used PNF technique through a progressively increased stability, as opposed to the GSE program [33]. Our results are similar to the study by Kofotolis and Kellis [20] that 4-week PNF programs may be appropriate for improving short-term trunk muscle endurance, trunk mobility and functional performance in women with LBP. Our results provided further support of previous findings on the positive effects of PNF techniques on trunk muscle endurance and joint flexibility.

The results of our study are applicable to adolescents with LBP. Also, findings of our study enable us to propose some recommendations for future research. It would be advisable for future studies to specify in the greatest possible detail the aspects of the treatments applied, such as type of PNF technique, duration and intensity. Also, the effectiveness of PNF modalities in managing acute or more intense LBP problems is unclear and deserves further investigation.

## 5. CONCLUSION

The application of sling bridge exercise and sling bridge exercise with rhythmic stabilization technique improved the trunk muscle endurance and flexibility in adolescents with low back pain. Because the SER group showed greater improvements, the use of PNF technique for the management of LBP appears to be more effective. These results suggest that spinal stabilization exercise seems to be effective for LBP in adolescents, with the combination of sling-bridge exercise and PNF technique showing the best results. The positive effects of the present training programs could be attributed to the nature of PNF exercise, which are designed primarily to maximize improvements in trunk muscle endurance and flexibility.

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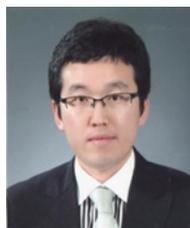
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