

Review

Effectiveness of Sling Exercise for Chronic Low Back Pain: A Systematic Review

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Abstract. [Purpose] This study investigated effects of sling exercise for patients with chronic low back pain. [Methods] We reviewed all relevant papers indexed in PubMed, SCOPUS, and the Cochrane Registered Trials. Eligible trials were randomized controlled trials that compared sling exercise with any type of treatment. We extracted data on muscle thickness, muscle activation, pain, and disability, and assessed the methodological quality of the data. Seven studies met our inclusion criteria. [Results] When sling exercise had an impact on activation of the trunk muscles, increasing the trunk muscle thickness, and the reduction in pain and disability had been assessed shortly after the final exercise session, it was more effective than general exercise at activating trunk muscles, but not more effective at increasing trunk muscle thickness and improving pain and disability than general exercise. [Conclusion] As sling therapy studies are based on a small number of trials, we cannot draw conclusions about the therapeutic effects of sling exercise. When segmental stabilizing exercise and individually designed programs are added to sling exercise, it increases the effectiveness of sling exercise at improving low back pain. This should be the focus of future studies.

Key words: Sling exercise, Chronic low back pain, Systematic review

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INTRODUCTION

Low back pain is a threat to public health and individuals' economic security^{1,2}. According to comprehensive reviews and epidemiological reports^{3,4}, the prevalence of low back pain ranges from 12% to 33%, the one-year prevalence ranges from 22% to 65%, and the lifetime prevalence ranges from 11% to 84%. Even in African populations where the prevalence of low back pain is believed to be low, it is a burden on society⁵. One study showed that although most patients with acute or persistent low back pain improve markedly within the first six weeks following therapy, pain and disability still remain after one year in some patients⁶.

Trunk muscles contribute to spine stability in healthy individuals with co-activation of trunk flexor and extensor muscles required for the stability of the lumbar spine⁷. Patients with low back pain have generalized weakness of the trunk muscles⁸. Some of these muscles are reported to

atrophy in adults with lumbar intervertebral disc herniation^{9,10}. There are a number of treatment modalities, such as sling exercise, motor control exercise, ball exercise and general exercise, for activating trunk muscles^{11,12,24,26}. Among these treatments, sling exercise has been widely used in Korea. The sling is a device with a swaying rope that is used to reduce the individual's weight load, similar to performing exercises in water. The unstable nature of sling exercise reduces pain and disability in patients with low back pain¹³. Sling exercise can improve trunk stability when combined with other types of exercise¹⁴. Numerous trials have investigated the effects of sling exercise on low back pain, chronic whiplash-associated disorders, balance, and pelvic girdle pain^{13,15,16}. Nonetheless, no study has reviewed the effectiveness of sling exercise. We therefore investigated whether sling exercise can strengthen trunk muscles and hence reduce pain and disability in patients with low back pain.

SUBJECTS AND METHODS

We performed a search of PubMed, SCOPUS, and the Cochrane Controlled Trials Register from their inception to December 2012. The search was performed using the search terms [{"low back pain" OR "back pain" OR "lumbago" OR "backache"}] AND "sling", without language restrictions.

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The types of study were randomized controlled trials. Participants had chronic low back pain with a duration of >12 weeks. The types of interventions considered were trials testing sling exercise as a sole therapy or as an adjunct. The types of controls included were any form of treatment including no treatment. The primary outcome measure was muscle attributes measured by ultrasonography (e.g., muscle thickness), electromyography or Tergumed (e.g., maximum voluntary isometric contraction). The secondary outcomes were pain and disability.

We independently extracted data on patient and treatment characteristics. If multiple studies described a single trial, they were considered as one trial. While extracting the data, we encountered a problem. For the muscle strength, most of the eligible trials reported data on the right side of the trunk, but several trials reported data for both sides. To maintain internal consistency, we extracted the data for the the right side. All disagreements were resolved by open discussion.

We independently assessed the methodological quality of the trials using the Physiotherapy Evidence-Based Database (PEDro) scale¹⁷⁾. One point was awarded whenever a study met one of the following criteria: (1) randomization was performed, (2) allocation was concealed, (3) the group baseline was similar, (4) the patient was blinded, (5) the therapist was blinded, (6) the assessor was blinded, (7) the dropout rate was under 15%, (8) an intention-to-treat analysis was performed, (9) two groups were compared by statistical analysis; and (10) point measures and variability were reported. When all the items were satisfied, 10 points were awarded. Trials with a PEDro score of greater than 5 are considered to be of moderate-to-high quality¹⁸⁾.

RESULTS

A total of 61 studies were identified: 21 from PubMed, 33 from SCOPUS, six from Cochrane Registered Trials, and one from another source (Fig. 1). Of these, seven trials^{19–25)} were finally included in our analysis. Data from one additional trial, a duplication of the trial by Unsgaard-Tøndel et al., were also included²⁶⁾.

Table 1 presents the characteristics of the seven studies were selected for review by this study. Three studies^{21–23)} scored <6 on the PEDro scale and the remaining trials scored ≥ 6 . All the studies except one²²⁾ involved small numbers of subjects (<50 patients in each group). In total, 209 patients took part in sling exercise, and 274 patients took part in the control program. When one study²⁰⁾, in which the average age of the patients was 70.4 years was excluded, the median age of the patients was 37.8 years (range: 20.3–43.2). The median proportion of female patients was 44.4% (range: 41.4–69.7) in all trials but one²⁰⁾, which included 90.9%. Regarding the type of control administered, five studies^{19–22, 25)} used general exercises, one¹⁹⁾ employed a motor control exercise, one²³⁾ used manipulation, one²⁴⁾ used a normal bridging exercise, and one²⁴⁾ used a ball-bridging exercise.

Muscle thickness ratios assessed by ultrasonography were reported by two studies (Table 2). The study by Vas-

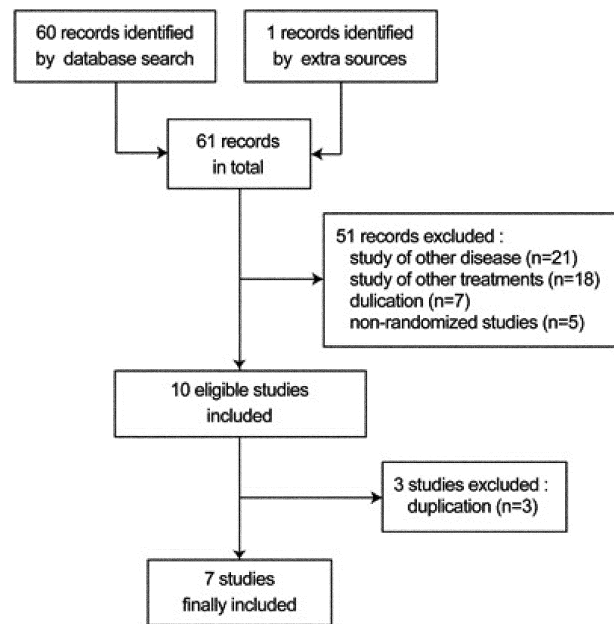


Fig. 1. Flow chart of the study selection procedure.

seljen and Fladmark²⁶⁾ found that, when the sling exercise was compared with general exercise, it was not more effective at increasing the thickness ratio of the transverse abdominis and obliquus internus. When compared with motor control exercise, the sling exercise was not more effective for the same outcome measures. The study by Saliba et al.²⁵⁾ showed that, when the sling exercise was compared with general exercise, it was not more effective at improving the thickness ratios of the transverse abdominis in a normal stance, a single leg stance, and an unstable surface stance. However, in the hip abduction stance, it had a significant effect on the thickness ratio of the transverse abdominis ($p < 0.05$).

Muscle activations evaluated by electromyography or Tergumed were reported by two studies (Table 2). The study by Kang et al.²⁴⁾ found that, when sling exercise was compared with normal bridging or ball-bridging exercises, it was significantly more effective at improving the maximum voluntary isometric contraction of the rectus abdominis, erector spinae, obliquus internus, and multifidus. The study by Yoo and Lee²¹⁾ also showed that compared with general exercises, the sling exercise was significantly more effective at increasing isometric contraction of the erector spine.

Pain outcomes were reported by four studies^{19–21, 23)} (Table 3). Three studies compared the sling exercise with general exercise and found that sling exercise did not significantly alleviate low back pain. However, the study by Gao et al.²³⁾ showed that sling exercise was more effective than manipulation reducing pain. Only two studies^{19, 20)} compared disability outcomes following sling exercise and general exercise (Table 3). They reported that sling exercise did not have any greater effect than general exercise.

Table 1. Characteristics of studies

	Age, Years (SD)	Female (%)	PEDro scale		Intervention		Treatment duration
			10 items* Sum	Experimental group	Control group		
Yoo, 2012. ²¹⁾	20.3 (0.6)		1010001011	5	1. Sling exercise (n=15) (body stretch, standing, pushing the upper body while seated, strengthening abdomen while standing, lying on the front, lying on the back)	1. General exercise (n=15) (preparatory exercise, belly blaster, cobra, butterfly, 3-stage pelvis stability exercise, hamstring stretch, folding knees to the chest, twisting the spine while lying down, abdominal breathing, cross extension, cobra) final abdominal breathing	3 days a week for 4 weeks
Schröder, 2012. ²⁰⁾	70.4 (5.1)	40 (90.9)	1110001011	6	1. Sling exercise (n=25) Phase 1: step aerobics, Phase 2: functional strength exercises focusing on correct posture, Phase 3: functional strength exercises for global surface muscles of the torso and dynamic sling, Phase 4: segmental stabilization, both static and dynamic (sling), Phase 5: stretching and relaxation	1. General exercise (n=25) (Phase 1: general keep-fit exercises, Phase 2: functional strength exercises focusing on correct posture, Phase 3: functional strength exercises for global surface muscles of the torso, Phase 4: segmental stabilization, both static and dynamic(exercise/ medical ball), Phase 5: stretching and relaxation)	2 days a week for 12 weeks
Ljunggren, 1997. ²²⁾	39.6 (10.0)	56 (44.4)	1110000011	5	1. Sling exercise (n=62) (lateral mobilization of the lower back, strengthening exercise for the oblique abdominals and the lower back, strengthening exercise for the back muscles between the shoulder blades, strengthening exercise for the abdominal muscles of the chest region, strengthening exercise for the inner thighs, strengthening exercise for the abdominal muscles, applying traction to the back strengthening exercise for the chest, shoulder and abdominal muscles	1. General exercise (n=62) (lifting the upper body in a hooklying position, Lifting the uppermost leg in a sidelying position, stretching the arm forwards and the opposite leg backwards while creeping, Lifting the upper body in a prone push up, lifting the feet off the floor in a prone position, standing up with the objects, trunk rotation, trunk bending)	3 days a week for 1 year
Gao, 2008. ²³⁾	36.0 (4.1)	12 (41.4)	1010111100	4	1. Sling exercise (n=15)	1. Manipulation (n=14)	5 days a week for 8 weeks
Kang, 2012. ²⁴⁾	43.2 (7.5)	13 (43.3)	1110001111	7	1. Sling exercise (n=30) (sling bridging exercise)	1. General exercise (n=30) (normal bridging exercise) 2. Ball exercise (n=30) (ball bridging exercise)	1 day
Unsgaard-Tøndel, 2010. ¹⁹⁾	40.1 (10.7)	76 (69.7)	1110011011	7	1. Sling exercise (n=36) (back exercise in sling)	1. Motor control exercise (n=36) (abdominal drawing-in maneuver) 2. General exercise (n=37) (general trunk strengthening and stretching exercises)	1 day a week for 8 weeks
Saliba, 2010. ²⁵⁾	23.1 (6.0)	33 (64.7)	1110011011	7	1. Sling exercise (n=26) (sling bridging exercise)	1. General exercise (n=25) (general bridging exercise)	1 day

*Ten items of PEDro scale: (1) randomization was performed; (2) allocation was concealed; (3) group baseline was similar; (4) patient was blinded; (5) therapist was blinded; (6) assessor was blinded; (7) dropout rate was under 15%; (8) intention-to-treat analysis was performed; (9) two groups were compared by statistical analysis; and (10) point measures and variability were reported.

Table 2. Effects of sling exercise on primary outcome

	Measure- ment time	Control group	Muscle type				
			Transverse abdominis	Rectus abdominis	Erector spinae	Obliquus internus	Multifidus
Muscle thickness ratio*							
Vasseljen, 2010. ²⁶⁾	2 months	1. General exercise	p>0.05	NA	NA	p>0.05	NA
		2. Motor control exercise	p>0.05	NA	NA	p>0.05	NA
Saliba, 2010. ²⁵⁾	1 day	1. General exercise	Normal stance: p=0.29 Single leg stance: p=0.79 Unstable stance: p=0.41 Hip abduction: p=0.04	NA	NA	NA	NA
Muscle activation							
Kang, 2012. ²⁴⁾	1 day	1. Normal bridging exercise	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	
		2. Ball bridging exercise	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	Maximum voluntary isometric contraction: p<0.05	
Yoo, 2012. ²¹⁾	1 month	1. General exercise		Isometric contraction: p<0.05			

NA, not applicable. * Ratios were calculated by dividing the thickness of the contracted muscle by that of the resting muscle.

DISCUSSION

This study investigated the effects of sling exercise therapy on the trunk muscle thickness ratio, muscle activation, pain, and disability. When the impact of sling exercise on the thickness of the trunk muscles was examined after the final treatment, it was not more effective than general exercise and motor control exercise at increasing the muscle thickness. However, hip abduction showed greater improvement in sling exercise groups than in control groups. After the intervention sling exercise was more effective than normal bridging exercise, ball-bridging exercise or general exercise at increasing trunk muscle activation. However, it was not more effective than general exercise at reducing pain or disability, although it was more effective than manipulation at reducing pain.

The trunk muscles of patients with low back pain show atrophy²⁷⁾. Pain changes the contraction pattern of trunk muscles and inhibits their activation²⁸⁾, eliciting atrophy of the trunk muscles. Also, patients with low back pain exhibit delayed contraction of the trunk deep muscles²⁹⁾. Trunk stability depends on normal recruitment of the deep muscles. Therefore, delayed contraction of these muscles causes instability of the trunk³⁰⁾. Previous investigations have found that trunk muscle strengthening and normal recruitment of the trunk muscles through neural adaption are effective at

reducing pain and disability and improving trunk stability^{31, 32)}. Therefore, trunk muscle strengthening and neural adaption via sling exercise can be expected to reduce the pain and disability of patients with low back pain.

Regarding muscle thickness, a previous study reported that motor control exercise was more effective than general exercise at increasing the muscle thickness of the transversus abdominis and lumbar multifidus³³⁾. Two other studies found that motor control exercise can increase the muscle thicknesses of the transversus abdominis and multifidus more than those of the other trunk muscles^{29, 34)}. In the studies selected for this review, sling exercise did not improve the muscle thickness of the transverse abdominis. Another study reported that 10 weeks of stabilization training combined with dynamic-static resistance training was more effective than general stabilization exercise or dynamic resistance training at increasing the thickness of the lumbar multifidus³⁵⁾. None of the studies reviewed in the present study presented any rationale for a particular duration of therapy. Changing the muscle thickness needs prolonged treatment over 10 weeks³⁶⁾. Therefore, the duration of the sling exercise applied in each trial may have been too short to increase the muscle thickness.

Regarding muscle activation, one study reported that bridging exercise on a Swiss ball was more effective at increasing trunk muscle activity than bridging exercise off a

Table 3. Effects of sling exercise on other outcomes

	Measurement time point	Control group	Pain	Disability
Unsgaard-Tøndel, 2010. ¹⁹⁾	2 months	General exercise	0–10 numeric pain scale: p>0.05	Oswestry disability index: p>0.05
Schröder, 2012. ²⁰⁾	3 months	General exercise	Pain domain of Qualeffo-41: p=0.43	Physical domain of Qualeffo-41: p=0.94
Yoo, 2012. ²¹⁾	1 month	General exercise	0–10 visual analogue scale: p>0.05	
Gao, 2008. ²³⁾	2 months	Manipulation	0–10 numeric pain scale: p<0.01	

Swiss ball³⁶⁾. There are some agreements between the results of this previous study and the findings of the present review. The similarities can be explained by the nature of the exercise surface. An unstable surface is more effective at increasing trunk muscle activation³⁷⁾. Therefore, the unstable characteristics of sling exercise may be more effective than general exercise at activating muscle activity. A long-term intervention does not seem to be needed. Another study reported that muscle activity was changed by neural adaptation through therapy lasting from days to a few weeks³⁸⁾. As noted above, despite the short-term nature of the intervention, sling exercise is more effective than general exercise at activating muscle activity.

Regarding pain and disability, a previous systematic review proposed strategies consisting of individually designed programs to improve pain and disability for nonspecific chronic low back pain³⁹⁾. Rackwitz et al. stated that segmental stabilizing exercises are more effective than treatment by a general practitioner for reducing the pain and disability of patients with low back pain⁴⁰⁾. In the present review, the sling exercises in the trials were not more effective than general exercise at reducing pain and disability. This discrepancy between the previous systematic review and our review can be explained by the nature of the programs. First, the treatment methods in the trials included in this review did not include segmental stabilizing exercises. Therefore, the sling exercise conducted in the studies reviewed may have been of insufficient intensity to reduce pain and disability. Second, sling exercise did not consist of individually designed programs.

Although this is the first review of the impact of sling exercise on low back pain, several considerations should be taken into account. In three (42.9%) of the seven studies examined, there was no mention of receipt of approval from an ethical review board^{21, 23, 24)}. Two studies did not state whether informed consent was obtained from the patients^{21, 23)}. Also, there were a small number of studies that were methodologically sound and had sufficient statistical power. As our review was based on a small number of trials, its conclusion are limited. Few trials have evaluated the effect of sling exercise over the long term. Hence, we cannot offer any broad insight into the therapeutic effect of sling exercise. The addition of segmental stabilizing exercise and individually designed programs to sling exercise programs should increase the effectiveness of sling exercise at reducing low back pain. This should be the focus of future studies.

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