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Original Article

# Effects of a therapeutic climbing program on muscle activation and SF-36 scores of patients with lower back pain

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**Abstract.** [Purpose] This study examined the effects of lumbar stability exercises on chronic lower back pain by using a therapeutic climbing program on lumbar muscle activity and function. [Subjects and Methods] Thirty adult subjects with chronic back pain participated. The subjects were assigned to 2 exercise groups, namely the lumbar stabilization (Mat Ex) and therapeutic climbing exercise groups (TC Ex). Each group trained for 30 minutes, 3 times a week for 4 weeks. The Short-form 36-item Questionnaire (SF-36) was administered and the surface electromyographic (sEMG) activities of the lumbar muscles were measured. [Results] Both therapy groups showed significant increases in the SF-36 score, and the increase was greater in the TC Ex group. Significant increases in the sEMG activities of the lumbar muscles were found in both groups. The increases in the sEMG activities of the rectus abdominis and internal and external oblique muscles of the abdomen were greater in the TC Ex group than in the Mat Ex group. [Conclusion] These findings demonstrate that TC Ex, which is similar to normal lumbar stabilization exercise, is effective at activating and improving the function of the lumbar muscles. These results suggest that TC Ex has a positive impact on the stabilization of the lumbar region.
**Key words:** Chronic lower back pain, Therapeutic climbing, Stabilization exercise

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## INTRODUCTION

Lower back pain causes improper posture and movement in an effort to avoid pain, resulting in abnormal muscle and ligament function that can limit the active range of motion[1)]. Patients with lower back pain have been observed on electromyograms, to display delayed muscle reactions, which would adversely affect trunk stability and increase the potential for lower back pain. In addition, the deep lumbar muscles of patients with lower back pain show greater muscle imbalance than subjects without lower back pain. This imbalance can cause destabilization of the spine due to decreased position sense arising from reduced proprioception, which can result in recurrence of lower back pain as well as muscle reduction and atrophy near the spine[2, 3)]. O'Sullivan found that the deep muscles in patients with lower back pain were weak compared to patients without lower back pain. They also found that patients with low back pain lacked position sense due to reduced proprioception function. Thus, spinal stability problems may lead to recurrence of lower back pain[4)].

The muscles associated with lumbar stability are attached to the spine. These muscles include the multifidus, transverse abdominis, and internal oblique muscles, that provide stability between the segments, and the major paraspinal and rectus abdominis muscles that aid general movement. For normal upright positioning, the muscles associated with trunk and pelvic stability must function normally[5)].

When a heavy or dynamic load is exerted in a standing position, the erector spinae, lumbar multifidus, and internal and external oblique muscles must be activated to stabilize the sacroiliac joint. Because most patients with lower back pain maintain the center of force at the rear of their base of support, the trunk muscles become relaxed and lumbar lordosis is increased compared to people without lower back pain. Poor standing posture influences static and dynamic motions that affect the entire body, and lead to musculoskeletal diseases[6)].

Co-contraction of the deep stabilizer and superficial stabilizer muscles as well as strengthening of the deep stabilizer muscles in the lumbar region are necessary. Co-contraction of the trunk muscles increases trunk rigidity (defined as the hardness of an elastic object), and as rigidity increases, stability also increases. Thus, joint stability increases with increased muscle tone, resulting from increased muscle activity[7, 8)].

Recently, lumbar stabilization exercises that improve lumbar spine stability and prevent lower back pain have been

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developed. These exercises strengthen the deep muscles of the spine by strengthening and enhancing intra-abdominal pressure through the development and control of the rectus abdominis and internal and external oblique muscles, leading to increased spinal stability[9]. Exercises that increase spinal stability can prevent micro-damage to discs, facet joints, and peripheral tissues by increasing the spine's ability to maintain a neutral posture[5]. Lower back pain patients who preform therapeutic exercises to improve lumbar stabilization report decreases in pain and increases in QOL[10], and many studies have demostrated the effectiveness of lumbar stabilization exercises[11, 12].

Therapeutic climbing is a new approach which has been adapted from artificial rock climbing motions. It is currently used as physical therapy for orthopedic, neurological, and psychological diseases as well as trauma[13]. Therapeutic climbing offers anaerobic exercise through movements of the upper and lower body against gravity as well as aerobic exercise through muscle and cardiovascular endurance incontinuous movements on a climbing wall. Isometric exercise at a climbing wall utilizes changing bases of support and effectiely generate of gravity to create static and dynamic movements. Stabilization exercises subject's like therapeutic climbing, can properly elicit muscle use through resistance to gravity, depending on the position[14, 15].

Most studies to date have examined the effects of therapeutic climbing on physical and functional skills as well as its psychological impact; however, studies are lacking on its benefits for patients with chronic lower back pain, especiallyts effects on activity levels and patterns of change in the deep trunk muscles. Therefore, this study performed a comparative analysis of therapeutic climbing and lumbar stabilization exercises performed on mats to determine the effect of therapeutic climbing on deep trunk muscles and their functional recovery.

## SUBJECTS AND METHODS

Thirty patients with ≥3 months' history of lower back pain agreed to participate in this study. The exclusion criteria included structural problems such as bone and nerve fractures, disc herniation, and previous lower limb or spine surgery. The subjects understood the principal objective of this study and provided their written informed consent before participating in the study. The study protocol was approved by the institutional review board of Dongshin University and was conducted in accordance with the ethical principles of the Declaration of Helsinki.

The patients were divided into 2 groups according to the exercises they were assigned to perform: lumbar-stability mat exercises (Mat Ex group; n = 15) and therapeutic climbing exercises (TC Ex group; n = 15). The patient characteristics are shown in Table 1.

**Table 1.** Subject characteristics

| | Age (years) | Height (cm) | Weight (kg) |
|---|---|---|---|
| Group I[b] | 33.6 ± 7.2[a] | 167.0 ± 8.7 | 65.8 ± 6.3 |
| Group II[c] | 34.9 ± 6.4 | 168.6 ± 6.9 | 63.1 ± 5.7 |

[a]Mean ± SD
[b]Group I: lumbar stability mat exercises (Mat Ex)
[c]Group II: therapeutic climbing exercises (TC Ex)

The Short-form 36-item Questionnaire (SF-36) was administered and the surface EMG (sEMG) activities of the lumbar muscles were measured before and after 4 weeks of therapy.

In the lumbar-stability mat exercises, the first movement was the supine bridging exercise, followed a the bridging exercise, which consisted of an upper or lower limb lift, and then the side bridging exercise, which consisted of the lower limb upward lift.

The therapeutic climbing exercise was performed on a 4 × 3 m, 90-degree-inclined therapeutic climbing wall. The therapeutic climbing exercise movements which change the base of support and center of gravity were selected to effectively generate static and dynamic movements. The first movement was the shoulder stability exercise, in which mimic the arms and legs are positioned further apart than shoulder width in the start position, and is followed by elbow flexion and extension to the push-up movement. Then, the subjects were instructed to perform one quasi-static climbing exercise on the therapeutic climbing wall. The initial position was indicated as both hands and feet on the wall, slightly wider than shoulder width. After 3 seconds of static holding, the subjects had to let go and move the left hand to laterally reach another climbing hold placed at the same height as the initial hold, but approximately 50 cm farther away. The subjects were advised to move their hand as slowly as possible, to take about 3 seconds to cover the distance between the holds[19]. Finally, for the upper and lower limb co-contraction movement, the subjects performed a squat movement on the therapeutic climbing wall. However, the holding hand was changed when alternating between sitting and standing (Table 2).

The independent t test was used to compare the groups. The within group comparisons were conducted using the paired t test. The significance level was chosen as $\alpha = 0.05$. All statistical analyses were performed using the Statistical Package for the Social Sciences version 12.0 software.

## RESULTS

Both therapy groups showed significant increases in SF-36 scores, and the increases were greater in the TC Ex group than in the Mat Ex group (Table 3). The erector spinae sEMG activity increased in both groups, with a greater increase in the Mat Ex group (Table 4). Compared with the Mat Ex group, the TC Ex group demonstrated greater increases in the sEMG activities of the rectus abdominis and internal and external oblique muscles of the abdomen (Table 4).

## DISCUSSION

Clinical back pain is commonly encountered, with more than 50% of the patients having lower back pain, which can spontaneously subside in 4–8 weeks. However, about 85% of patients experience relapse within 1 year and eventually develop chronic lower back pain, especially those with trunk instability due to spinal muscular atrophy[16, 17]. The goal of

**Table 2.** Exercise programs

| Level | Content | | |
|---|---|---|---|
| Lumbar stabilization exercises (Mat Ex) | Bridging exercise | | |
| | Bridging exercise and trunk control (lift one limb) | | |
| | Side frank exercise and dynamic stability (lift one lower limb) | | |
| Therapeutic climbing exercises (TC Ex) | Shoulder stability exercise | | |
| | Shoulder stability and trunk control (upper limb horizontal abduction) | | |
| | Dynamic stability (in climbing wall and jump holder change) | | |
| Sets/repetitions | 10 times/10 sec/3 sets | Rest | 30 sec/set |

**Table 3.** Short-form 36-item Questionnaire scores of in each therapy group (score)

| | | Before | 4 weeks | Change |
|---|---|---|---|---|
| Physical functioning | Group I[b] | 66.0 ± 13.5[a] | 80.7 ± 11.9* | 14.7 ± 1.6 |
| | Group II[c] | 65.4 ± 17.6 | 83.2 ± 13.2* | 17.8 ± 4.5# |
| Role limitation (physical) | Group I[b] | 76.1 ± 15.6 | 103.3 ± 24.7* | 27.2 ± 9.1 |
| | Group II[c] | 80.3 ± 14.1 | 108.7 ± 28.4* | 28.4 ± 14.2 |
| Bodily pain | Group I[b] | 60.7 ± 16.6 | 85.7 ± 24.9* | 25.0 ± 8.3 |
| | GroupII [c] | 63.2 ± 17.4 | 90.4 ± 23.6* | 27.2 ± 6.1 |
| General health | Group I[b] | 63.4 ± 15.8 | 87.4 ± 14.2* | 24.0 ± 1.6 |
| | GroupII [c] | 64.4 ± 13.7 | 90.8 ± 22.8* | 26.4 ± 9.0# |

Group I: lumbar stability mat exercises, Group II: therapeutic climbing exercises

**Table 4.** Muscle activities of in each therapy group (%RMS)

| | | Before | 4 weeks |
|---|---|---|---|
| Erector spinae | Group I[b] | 95.4 ± 7.0[a] | 113.6 ± 14.6* |
| | GroupII[c] | 94.1 ± 4.7 | 121.5 ± 16.3##* |
| Rectus abdominis | Group I[b] | 90.4 ± 6.2 [a] | 100.8 ± 7.8* |
| | Group II[c] | 88.3 ± 8.4 | 111.9 ± 4.9##* |
| External oblique | Group I[b] | 94.7 ± 7.4[a] | 106.4 ± 6.3* |
| | Group II[c] | 93.4 ± 5.8 | 110.3 ± 7.1#* |
| Internal oblique | Group I[b] | 90.5 ± 9.6 | 103.5 ± 8.2* |
| | Group II[c] | 91.7 ± 7.8 | 105.3 ± 9.4* |

[a]Mean ± SD
[b]Group I: lumbar stability mat exercises (Mat Ex), [c]Group II: therapeutic climbing exercises (TC Ex).
#p < 0.05, ##p < 0.01; ###p < 0.001 (independent t test)
*p < 0.001 (paired t test).

lumbar stabilization exercise is to restore the function of the abdominal trunk muscles and spinal posture to facilitate the reduction of the pain intensity in the ligaments and joint capsule of sensitive organs and to reduce the retricition of the joint range of motion[18)].

The effectiveness of therapeutic climbing as a complement to conventional physiotherapy has been proven in different fields of rehabilitation[19)]. Climbing appears to be well suited to the promotion of core strength and trunk mobility. In fact, climbing is characterized by continuous changes in dynamic and isometric contractions[20)].

In this study, we investigated whether therapeutic climbing exercise, which focuses on the movement of the shoulder joint stabilizer muscles, could minimize the load on the spine and thereby enhance the superficial muscle and stabilize the trunk.

The SF-36 results showed significant increases in scores in both exercise groups after the 4 weeks of therapy. However, the increases in SF-36 scores were greater in the TC Ex group than in the Mat Ex group. These findings are important given that a previous study demonstrated that patients with a lower SF-36 score are more likely to respond favorably to stabilization exercise[21)].

To evaluate the stabilization of the spine, we examined the sEMG activities of the rectus abdominis, erector spinae, and internal and external oblique muscles of the abdomen. The increase in erector spinae sEMG activity was greater in the Mat Ex group than in the TC Ex group. In contrast, the TC Ex group demonstrated greater increases in the sEMG activities of the rectus abdominis, and internal and external oblique muscles of the abdomen. In line with these findings, a previous study that examined the muscle activities of the rectus abdominis, and internal and external oblique muscles of the abdomen during movement of the arms and legs, demonstrated that these muscles provide stability to the pelvis and trunk, and maintain the stability of the spine[22)]. The similarities of therapeutic climbing with common sports have a motivational effect on patients, which makes it more attractive than other rehabilitation exercises. Highly controllable movements adapted from sports climbing are characteristic of therapeutic climbing. It has been reported to help patients overcome fears and to increase their self-discipline. Especially in back pain therapy, there is a high potential for the use of therapeutic climbing[23, 24)].

This study had some limitations. Because the study period was short, the results cannot be generalized across different populations. However a therapeutic climbing program based on the the stabilizer muscles of the rectus abdominis muscle during rehabilitation can activate the features of oblique movements and thus improve and stabilize the lumbar trunk muscles during exercise.

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