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# Effects of Push-ups Plus Sling Exercise on Muscle Activation and Cross-sectional Area of the Multifidus Muscle in Patients with Low Back Pain

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**Abstract.** [Purpose] The purpose of this study was to examine the effect of lumbar stability exercises on chronic low back pain by using sling exercise and push-ups. [Subjects] Thirty adult subjects with chronic back pain participated, with 10 adults being assigned to each of 3 exercise groups: general physical therapy (PT), lumbar stability using sling exercises (Sling Ex), and sling exercise plus push-ups (Sling Ex+PU). Each group trained for 30 minutes 3 times a week for 6 weeks. The Oswestry Disability Index (ODI), surface electromyographic (sEMG) activity of the lumbar muscles, and cross-sectional area of the multifidus muscle on computed tomography (CT) were evaluated before and at 2, 4, and 6 weeks of therapy. [Results] A significant decrease in ODI was seen in all therapy groups, and this change was greater in the Sling Ex and Sling Ex+PU groups than in the PT group. No changes in sEMG activity were noted in the PT group, whereas significant increases in the sEMG activities of all lumbar muscles were found in the other 2 groups. The increases in the sEMG activities of the rectus abdominis and internal and external oblique muscles of the abdomen were greater in the Sling Ex+PU group than in the other 2 groups. [Conclusion] These findings demonstrate that Sling Ex+PU, similar to normal lumbar stabilization exercise, is effective in activating and improving the function of the lumbar muscles. These results suggest that Sling Ex+PU has a positive impact on stabilization of the lumbar region.
**Key words:** Chronic low back pain, Push-up plus, Multifidus muscle

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## INTRODUCTION

Physical activity is reduced in approximately 15% of patients with low back pain. Back pain disorders, followed by more than 3 months of physical inactivity, lead to a reduction in spinal alignment and deformation of musculoskeletal structures, due to the negative effects on bone mineral density, decreases in muscle strength and muscle atrophy. Indeed, 98% of low back pain disorders are caused by musculoskeletal problems[1, 2)].

The contractions of the transverse and multifidus muscles are responsible for maintaining the stability of the lumbar spine[3)]. Previous studies have demonstrated that the weakened lumbar muscles in patients with low back pain, especially the multifidus, do not heal naturally. For example, Hides et al. indicated that the strength of the most important deep lumbar stabilizer muscles does not improve with resistance exercise in patients with low back pain. Furthermore, in cases of reduced strength because of pain, Hides et al. reported that selective strengthening exercise for the multifidus is problematic because it is difficult to detect capacity degradation due to the mechanical movement of deep muscles[4–6)].

The deep stabilizer muscles in patients with low back pain are weak and unbalanced, consequently causing a reduction in proprioceptive sense (posture or kinesthetic), which can subsequently lead to stability problems in the spine and the recurrence of back pain[7)]. It has been suggested that in order to stabilize the trunk, co-contractions of the deep superficial muscles of the lumbar region are necessary in order to strengthen the deep stabilizer muscles that are directly attached to the spine[8)]. The sling exercise technique is suitable for these purposes and is a concept of active neuromuscular control. Using the appropriate tools and a swaying line, this method of exercise revitalizes the muscle by stimulating the nerve root with static-dynamic muscle contraction movement, and at the same time, it eases the joint load with traction weight[9)]. This technique is effective for soft tissue relaxation in dysfunction and pain due to musculoskeletal problems; it increases the joint range of motion and traction and stabilizes and strengthens muscle tissue[10)]. Through the movement involved in push-ups plus sling exercise, it is possible to apply a stabilized movement

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**Table 1.** Subject characteristics

| | Age (years) | Height (cm) | Weight (kg) |
|---|---|---|---|
| Group [b] | 39.6±6.2[a] | 163.0±6.1 | 63.8±5.9 |
| Group [c] | 39.9±5.8 | 166.6±7.3 | 62.5±4.8 |
| Group [d] | 40.5±5.4 | 165.8±6.0 | 62.5±4.00 |

[a]Mean ± SD
[b]Group I: general physical therapy (GPT), [c]Group II: GPT + lumbar stabilization exercise using sling, [d]Group III: GPT + push-up plus exercise using sling

**Table 2.** Sling exercise programs

| Level | | Content | | |
|---|---|---|---|---|
| Lumbar stabilization exercise | 1 | Prone lumbar setting | Bridging exercise | |
| | 2 | Supine pelvic lift | Supine pelvic lift and abduction | |
| | 3 | Side lying hip abduction | Side lying hip adduction | |
| Push up plus exercise | 1 | Quadrupedal position | | |
| | 2 | Prone position | | |
| | 3 | Standing position | | |
| Sets/repetitions | | 5 times/3 sec/3 sets | Rest | 30 sec/set |

to induce the contraction of trunk muscles. While this approach has been reported to functionally improve back pain in some patients, objective evaluation and application of this treatment is scarce[11].

Therefore, in this study, we investigated whether training methods that contribute to stabilization of the trunk, such as push-ups plus sling exercise that focuses on strengthening the stabilizer muscles of the shoulder joint, minimize the load on the spine in patients with low back pain.

## SUBJECTS AND METHODS

Thirty patients with 3 months of low back pain agreed to participate in this study. Exclusion criteria included structural problems, such as bone and nerve fracture, disc herniation, and previous lower limb and spine surgery. The subjects understood the principal objective of this study and provided their written informed consent before participating in the study This protocol was approved by the Institutional Review Board of Dongshin University and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

The patients were divided into 3 exercise groups: general physical therapy (PT; n = 10), general physical therapy and lumbar stability using sling exercises (Sling Ex; n = 10), and general physical therapy and push-ups plus sling exercises (Sling Ex+PU; n = 10). The patient characteristics are shown in Table 1.

General physical therapy similar to that commonly used in patients with chronic low back pain, including administration of a hot pack (80 °C, 10 minutes), intermittent/continuous traction (2,000–2,500 Hz, 15 minutes), and ultrasound (0.8–1 MHz, 5 minutes), was used. As shown in Table 2, lumbar stability exercises in the Sling Ex and Sling Ex+PU groups were performed for 30 minutes at level 1 during week 1, levels 1–2 for weeks 2–3, levels 1–3 for weeks 4–5, and levels 1–3 for week 6. The subjects performed the exercise programs for 30 minutes 3 times a week for 6 weeks. The Oswestry Disability Index (ODI), surface electromyographic (sEMG) activity of the lumbar muscles, and cross-sectional area of the multifidus muscle on computed tomography (CT) were evaluated before and at 2, 4, and 6 weeks of therapy.

A one-way ANOVA with a Tukey's multiple range post-hoc test, was used to compare each group over time. Comparisons of groups at each time-point were conducted using a paired t-test. The significance level was set at $\alpha = 0.05$. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 12.0 software.

## RESULTS

A significant decrease in ODI was seen in all 3 therapy groups. However, after 2 weeks, greater decreases in ODI were noted in the Sling Ex and Sling Ex+PU groups, and these changes persisted for the entire 6-week period (Table 3). While no changes in sEMG activity were seen in the PT group (Tables 4–8), after 6 weeks of therapy, the erector spinae sEMG activity was increased in the other 2 groups, with a greater change in the Sling Ex group compared with the Sling Ex+PU group (Table 4). However, in comparison with the other 2 groups, the Sling Ex+PU group demonstrated greater increases in the sEMG activities of the rectus abdominis and internal and external oblique muscles of the abdomen. The cross-sectional area of the multifidus muscle on CT was unchanged in the PT group and significantly increased in both the Sling Ex and the Sling Ex+PU groups. In selective examination of the sling exercise therapy groups, the increase in the cross-sectional area of the multifidus muscle was significantly greater in the Sling Ex group than in the Sling Ex+PU group.

**Table 3.** Oswestry Disability Index over time in each therapy group (Unit: %RMS)

| | Before | 2 weeks[1] | 4 weeks[2] | 6 weeks[3] |
|---|---|---|---|---|
| Group [b] | 44.8±3.2 [a] | 41.9±5.8 | 38.9±5.00** | 37.3±5.00*** |
| Group [c] | 45.1±3.6 | 38.2±4.1** | 31.5±4.2††*** | 25.1±4.1†††*** |
| Group [d] | 46.4±3.1 | 36.5±3.9†*** | 32.2±3.7††*** | 27.3±3.0†††*** |

**Table 4.** Erector spinae muscle activity over time in each therapy group (Unit: %RMS)

| | Before | 2 weeks[1] | 4 weeks[3] | 6 weeks[3] |
|---|---|---|---|---|
| Group [b] | 97.9±8.0 [a] | 96.8±9.6 | 96.2±8.7 | 95.1±10.5 |
| Group [c] | 99.3±7.3 | 110.5±9.5†** | 120.4±10.0†††*** | 129.6±12.1†††*** |
| Group [d] | 98.6±12.2 | 104.5±12.9*** | 111.6±13.0††*** | 118.3±13.4†††*** |

**Table 5.** Rectus abdominis muscle activity over time in each therapy group (Unit: %RMS)

| | Before | 2 weeks[2] | 4 weeks[3] | 6 weeks[3] |
|---|---|---|---|---|
| Group [b] | 90.5±6.5 [a] | 89.2±6.7 | 90.3±6.5 | 90.7±7.8 |
| Group [c] | 89.0±5.8 | 94.3±6.3*** | 100.5±6.8†*** | 111.9±7.3†††*** |
| Group [d] | 91.7±5.5 | 103.2±9.1††≠*** | 112.9±9.8†††≠≠*** | 123.0±8.9†††≠≠*** |

**Table 6.** External oblique muscle activity over time in each therapy group (Unit: %RMS)

| | Before | 2 weeks[2] | 4 weeks[3] | 6 weeks[3] |
|---|---|---|---|---|
| Group [b] | 95.9±5.9 [a] | 95.9±5.0 | 97.3±4.6 | 96.8±4.0 |
| Group [c] | 95.2±7.1 | 103.0±7.1†** | 107.3±6.6††*** | 113.5±7.8†††*** |
| Group [d] | 94.9±7.8 | 105.2±6.2††** | 113.0±7.4†††*** | 120.0±8.1†††*** |

**Table 7.** Internal oblique muscle activity over time in each therapy group (Unit: %RMS)

| | Before | 2 weeks | 4 weeks[2] | 6 weeks[3] |
|---|---|---|---|---|
| Group [b] | 93.7±5.4 [a] | 93.5±5.6 | 94.1±5.3 | 94.5±6.7 |
| Group [c] | 92.5±5.7 | 97.1±6.4*** | 103.2±6.4†*** | 111.2±6.7††*** |
| Group [d] | 93.4±9.0 | 99.7±8.5*** | 105.7±9.5††*** | 114.7±12.0†††*** |

**Table 8.** The change in multifidus muscle cross-sectional area in each therapy group (Unit: $mm^2$)

| | Left[3] | Right[3] |
|---|---|---|
| Group [b] | 0.2±0.5[a] | −0.2±0.5 |
| Group [c] | 11.5±3.8††† | 11.2±3.2††† |
| Group [d] | 7.5±2.0†††≠≠ | 7.0±2.1†††≠≠≠ |

[a]Mean ± SD
[b]Group I: general physical therapy (GPT), [c]Group II: GPT + lumbar stabilization exercise using sling, [d]Group III: GPT + push-up plus exercise using sling
[1]p < 0.05, [2]p < 0.01; [3]p < 0.001(one way ANONA)
†p < 0.05, ††p < 0.01; †††p < 0.001: PT vs. Sling Ex and Sling Ex+PU (Tukey post hoc test)
≠p < 0.05, ≠≠p < 0.01; ≠≠≠p < 0.001: Sling Ex vs. Sling Ex+PU (Tukey post hoc test)
*p < 0.05,**p < 0.01; ***p < 0.001 (paired t-test)

## DISCUSSION

The superficial multifidus muscle is a deep spinal muscle that covers multiple levels of the spine and, along with the erector spinae, plays a role in rotating and extending the spine. The deep multifidus muscle has a high reaction rate and contributes to stabilization of the spine[12)]. Previous studies have indicated that lumbar segmental stabilization using multifidus strength training decreases pain and reduces the relapse rate of back pain[13–15)]. In this study, we investigated whether push-ups plus sling exercise, which focuses on the movement of the shoulder joint stabilizer muscles, could minimize the load on the spine and thereby enhance the superficial and deep trunk muscles and stabilize the trunk.

Examination of the ODI results over time showed a significant decrease in both sling exercise groups after 2 weeks of therapy. However, by 6 weeks, the decrease in ODI was greater in the Sling Ex+PU group than in the Sling Ex group. These findings are important given that a previous study demonstrated that patients with a lower ODI score are more likely to respond favorably to stabilization exercise[16].

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. No changes in sEMG activity were seen in the PT group. Interestingly, the increase in erector spinae sEMG activity was greater in the Sling Ex group than in the Sling Ex+PU group. In contrast, the Sling Ex+PU 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, which 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 also maintain the stability of the spine (particularly the oblique muscles of the abdomen)[17]. Therefore, Sling Ex+PU therapy, involves exercise on an unstable surface and arm motion with the trunk fixed, causes high activation of the rectus abdominis and internal and external oblique muscles of the abdomen.

The multifidus muscle cross-sectional area showed no changes in the PT group, whereas significant increases were seen in the Sling Ex and the Sling Ex+PU therapy groups, with the greater increase occurring the Sling Ex group. Michael and Andre have also reported that stabilization exercise of the lumbar region using an unstable support surface (Swiss ball) maintained the stability of local muscles by activating muscles that are not normally used[18].

The results of the present study indicate that Sling Ex+PU, with a focus on strengthening the stabilizer muscles of shoulder joint, improves functional movement by activating the rectus abdominis and the internal and external abdominal oblique muscles. This approach could be used during early rehabilitation for patients with chronic low back pain when weight-bearing exercise cannot be used because of pain and limited mobility. We believe that Sling Ex+PU is similar to lumbar stabilization exercise and can lead to increases in lumbar strength. The limitations of this study were examination of 1 region alone and the short-term follow-up period. The influences of spinal stabilization muscles other than the multifidus were also not considered.

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