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Original Article

Effects of lumbar stabilization exercises on the flexion-relaxation phenomenon of the erector spinae

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Abstract. [Purpose] This study evaluated the differences in the flexion-relaxation phenomenon (FRP) of the right and left erector spinae muscles in asymptomatic subjects and the effect of lumbar stabilization exercises on these differences. [Subjects and Methods] Twenty-six participants (12 in the exercise group and 14 in the control group) with a difference in the FRP in the right and left erector spinae muscles were recruited from among healthy students attending Silla University. The exercise group performed two lumbar stabilization exercises (back bridge exercise and hand-knee exercise) for 4 weeks. The control group did not exercise. [Results] No significant group-by-exercise interaction was found. The right and left erector spinae muscles did show a difference in FRP between the control and exercise groups (119.2 ± 69.2 and 131.1 ± 85.2 ms, respectively). In addition, the exercise group showed a significant decrease in post-exercise (50.0 ± 27.0 ms) compared to pre-exercise (112.3 ± 41.5 ms) differences in the right and left FRP. [Conclusion] These results suggest that lumbar stabilization exercises may counter asymmetry of the FRP in the erector spinae muscles, possibly preventing low back pain in the general population.
Keywords: Flexion-relaxation phenomenon, Low back pain, Lumbar stabilization exercise

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INTRODUCTION

The flexion-relaxation phenomenon (FRP) is the myoelectric silencing of a muscle during a full-flexion maneuver[1)]. The FRP of the erector spinae (ES) muscles shows silencing during upright to full-flexion lumbar movement in asymptomatic subjects. The phenomenon involves the transfer of the role of the extension moment producer to the deep back muscles to achieve spinal stability[2)]. Patients with low back pain (LBP) exhibit laxity of passive structures and an altered neuromuscular activation pattern in the back muscles, in which the FRP of the ES muscles is not present. Thus, the FRP of ES muscles has been used to evaluate LBP and to monitor intervention-related factors after treatment[3)].

Previous studies have shown that FRP occurs with full lumbar flexion in the sagittal plane. However, asymptomatic and symptomatic subjects can produce asymmetric lumbar flexion by lumbar flexion combined with lateral bending and axial rotation. Although most healthy people do not have LBP, they have the potential for asymmetry in the FRP in the right and left ES muscles due to repetitive movement and poor posture in their work environments or daily activities. Ning et al.[4)] reported that asymmetric lumbar flexion elicits a loss of the FRP in the ipsilateral muscle in asymptomatic subjects. Although 90% of non-LBP subjects show FRP[5)], many of them were at risk of LBP, because of asymmetry in the FRP of the ES muscles.

Currently, LBP patients perform various deep muscle strengthening exercises for lumbar tissue, with Pilates, sling exercises, and lumbar stabilization exercises being the most common[6)]. Lumbar stabilization exercises, especially the back bridge and hand-knee position, are the most effective at strengthening the multifidus muscle[7)]. Marshall and Murphy et al.[3)] reported that a 12-week exercise program (side bridge, supine bridge, partial curl-up, bird-dog exercise, Swiss ball push-up, single leg

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hold, and rollouts) decreased self-reported pain and ES muscle activity during the relaxation phase of FRP tests in patients with chronic non-specific LBP. Lumbar stabilization exercises elicit a reappearance of the FRP through strengthening of the multifidus muscle, and eventually this could result in symmetry of the FRP in non-LBP subjects with an asymmetric FRP of the ES muscles.

The purpose of this study was to evaluate differences in the FRP in the right and left ES muscles in asymptomatic subjects. In addition, the effects of lumbar stabilization exercises on differences in the FRP of the right and left ES muscles were investigated.

SUBJECTS AND METHODS

Participants (*n*=30; average age, 19.8 ± 1.1 years; height, 164.5 ± 7.4 cm; body mass, 57.54 ± 7.20 kg) were recruited from among the healthy student population of Silla University. Participants were excluded from the study if they had a history of back pain, vertebra surgery, or neuromuscular disorders. All participants provided their written informed consent prior to participation. All procedures were reviewed and approved by the ethics committee of Silla University.

To analyze the FRP of the ES muscles, surface electromyography (EMG) (MyoTrace 400; Noraxon Inc., Scottsdale, AZ, USA) was used with two bipolar surface EMG electrodes placed bilaterally 2 cm apart over the right and left L3 area. The collected surface EMG data were analyzed using MyoResearch software (ver. 1.08 XP). The data were collected at 1,000 Hz and processed using a 20–450 Hz band-pass filter and a 60-Hz notch filter. The root mean square moving average of 300 ms duration of the processed EMG data was calculated. The relaxation time was defined as when ES activation decreased by two standard deviations (SD) of silence activation in the fully flexed lumbar phase. The absolute value of the difference in relaxation time measured in the right and left ES was calculated. The experiment was done in triplicate and the calculations were based on the averages of the three trials. The subjects were examined from upright to full-forward lumbar flexion. The position of the feet was marked for consistency between trials. In all trials, the move from upright to full-forward flexion (forward flexion phase) was performed over 3s, followed by 3s maintenance of full flexion posture (fully flexed phase), and another 3 s to move from full-forward flexion to the upright posture (re-extension phase)[8, 9].

Participants were assigned randomly to the control or exercise group using a table of random numbers. The control group did not exercise. The exercise group performed two exercises that are commonly used in clinical practice and have been used in previous studies (back bridge and hand-knee exercise). These exercises were performed 3 days per week with a trainer and 2 days per week at home for 4 weeks. The exercises were done in three sets with three repetitions per set and a set break of 3 min. All exercises were performed on a mat. Instructors provided feedback to ensure that a consistent supine and lower limb posture was maintained during the exercise. For the back bridge exercise, the subjects lay supine on the floor with their feet flat on the ground, their knees bent at 90°, their toes facing forward, and their hands on the floor by their sides. With their palms facing down, the subject raised the pelvis to achieve and maintain a neutral hip flexion angle. The subjects were requested to raise the back bridge from the floor (stable condition) and hold the posture for 1 min. After the 1-min hold, the subject was given a 30-s break. For the hand-knee exercise, the subjects started on their hands and knees with a neutral pelvis position and breathing normally. They lifted and held straight the right arm and the left leg before doing the same with the opposite set of limbs. The subjects held each position for 40 s with a 30-s break between positions.

SPSS software (ver. 18.0) was used to test the significance of differences between the exercise and control groups and between pre- and post-exercise. A subject factor analysis was used to assess the statistical significance of the FRP in the ES muscles with a repeated two-way analysis of variance. The paired t-test was used to test the significance of differences between the two groups' characteristics. The results are expressed as means ± SD, and α=0.05 used set as the level of statistical significance.

RESULTS

A difference was seen in the FRP between the right and left ES muscles in asymptomatic subjects (control group 119.2 ± 69.2 ms and exercise group 131.1 ± 85.2 ms; $p>0.05$). No significant group-by-exercise interaction was found ($p>0.05$). The exercise group showed a significant decrease post-exercise (50.0 ± 27.0 ms) versus pre-exercise (112.3 ± 41.5 ms) in the right and left FRP of the ES muscles ($p<0.05$).

DISCUSSION

In this study, the healthy participants showed a difference in the right and left FRP in the ES muscles. This lack of balance in the FRP is thought to result from repetitive asymmetric posture and activity. Previous research has indicated there is an increased risk of back pain when working in asymmetric positions[9]. Asymmetric postures produce passive spinal postural deconditioning in the lumbar stabilizing muscles. Motor control deficits and motor dysfunction result in increased passive system loading from repeated stress[10]. The students who participated in this experiment spent a great deal of time at school in a sitting position. This does not produce LBP, but they exhibited an asymmetric FRP in the right and left ES muscles. Callaghan[11] reported a difference in activation between the right and left ES in healthy subjects (right 15 and left 17 of 20 participants). Furthermore, the FRP was not detected in 20% of healthy subjects. This indicates that asymptomatic people can have impairment and imbalance in the FRP. When the students exhibited poor posture (e.g., sitting cross-legged or one-leg weighted standing) they experienced no pain, but they demonstrated potential factors for LBP.

The bridge exercise is a popular lumbar stabilization exercise that activates weak abdominal muscles and prevents unstable lumbar spine movement via co-activation of the pelvic floor muscles, diaphragm, and deep abdominal muscles[12]. Additionally, the Swiss ball exercise activates deep and superficial abdominal muscles by using the characteristics of an unstable environment[13]. Marshall and Murphy[14] reported that Swiss ball exercises increased the FRP (from 3.26 ± 3.43 to 6.53 ± 3.34) in LBP patients. In the present study, lumbar stabilization exercises improved muscular balance by reducing asymmetry in FRP onset. Howarth et al.[15] reported that back muscle instability caused by slumped sitting delayed the onset of the FRP. Likewise, the intervention used in the present study was meaningful for trunk asymmetry and instability. At the onset of the FRP, the external moment generated around the lower back by the upper body's mass is counteracted by the net internal moment produced from the tensile forces developed in elongated passive tissue, instead of the forces generated by the active component of the lower back musculature[16]. Thus, lumbar stabilization exercises can improve the motor control of lumbar spinal movement and lumbar stabilization control.

Among the various exercises used for lumbar stabilization, the sling and Swiss ball exercises show the highest EMG activation values[17]; however, this study used the back bridge and hand-knee exercises. These two exercises do not need any special equipment or space, so they are more suited for home-based exercise than sling or ball exercises. Additional studies are needed to measure changes in the FRP in the ES muscles elicited by other lumbar stabilization exercises.

While further study is needed, the results of this study suggest that lumbar stabilization exercises can help to correct asymmetry of the FRP in the right and left ES muscles and this would help prevent LBP in the general population.

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