

Selective Activation of Lumbar Paraspinal Muscles during Various Exercises in the Prone Position as Measured by EMG

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Abstract. [Purpose] This study compared the effects of three exercises performed in a prone position on the selective activation of the lumbar erector spinae (LES) and lumbar multifidus (LM) muscles in healthy males to investigate the effective method for selective activation of the LM. [Subjects] Twenty-two healthy males were recruited. Surface EMG data were collected from the right LES and LM muscles during three exercises: 1) trunk extension, 2) hip extension, and 3) the arm lift. [Results] The ratio of LM to LES EMG activity during hip extension was higher than those during trunk extension and the arm lift. [Conclusion] Hip extension in a prone position may be effective for selective activation of the lumbar multifidus muscles in healthy males.

Key words: Lumbar erector spinae, Lumbar multifidus, Selective activation

(This article was submitted Jan. 17, 2014, and was accepted Feb. 16, 2014)

INTRODUCTION

The lumbar paraspinal muscles play a key role in providing stability during dynamic exercises¹⁾. The lumbar multifidus (LM) is a significant local stabilizer of the lumbar spinal segment, and therapeutic exercises in patients with low-back pain (LBP) emphasize strengthening the LM²⁾. On the other hand, the lumbar erector spinae (LES) muscles form a global stabilizing system for trunk stability, and high LES activity is associated with increased spinal loading³⁾, which may aggravate pain or even be harmful in LBP patients. In a recent study, selective activation of the LM, independent of the other lumbar paraspinal muscles, was stressed as the target of exercise interventions²⁾. Many researchers have reported high activity in the lumbar paraspinal muscles, which are responsible for lumbar stabilization during various exercises, and lumbar extensor exercises in a prone position have been recommended for lumbar paraspinal muscle strengthening⁴⁾. Jari et al.⁵⁾ reported high activation of the LM during trunk extension and hip extension in a prone position, and Jeffrey et al.⁶⁾ suggested the arm

lift exercise in a prone position as a means of activating LM function. Although many exercises have been suggested as exercises for strengthening the lumbar paraspinal muscles, no study has examined selective activation of the lumbar paraspinal muscles in a prone position, such as trunk extension, hip extension, and the arm lift, in healthy males. Therefore, this study investigated selective activation of the lumbar paraspinal muscles during various exercises in a prone position in healthy males.

SUBJECTS AND METHODS

Twenty-two healthy males aged 19–26 years volunteered for this study. The inclusion criteria were no chronic LBP and the ability to participate in the exercises safely. The subjects' mean age was 21.82 ± 2.22 years, and their mean height and weight were 174.91 ± 5.96 cm and 68.11 ± 8.96 kg, respectively. All individuals reported that they were right-hand and right-leg dominant. All subjects read and signed an informed consent form approved by the Inje University Ethics Committee for Human Investigations prior to participation.

The EMG data were recorded and analyzed using a surface EMG system (MP150, Biopac Systems, Inc., Santa Barbara, CA, USA). After the skin at the electrode sites was shaved and cleaned with alcohol swabs, right-side surface EMG data were collected from the LES (2 cm lateral to the spinous process of the L2 level and aligned parallel

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to the spine; Criswell, 2010) and LM (2 cm lateral to the midline running through the L5 spinal process and aligned parallel to the muscle fibers; Cram et al., 1998). The signals were amplified and band-pass filtered (20–500 Hz) before being recorded digitally at 1,000 Hz, and then the root mean square (RMS) was calculated. Maximum voluntary isometric contractions (MVICs) were performed against manual resistance for all muscles⁷⁾. Each MVIC maneuver was performed twice for 5 s, and the average muscle activity for the middle 3 s of each of the two trials was used for normalization. The LM/LES ratio was calculated to assess selective activation of the lumbar paraspinal muscles during each exercise.

The subjects were asked to lie prone with their arms at their sides and their head in the midline. The three exercises in the prone position were performed as follows. For trunk extension, subjects were instructed to extend the trunk as far as possible; for hip extension, they were asked to extend the right hip as far as possible, while maintaining normal lumbar lordosis; and for the arm lift, they were asked to lift the right arm as far as possible, with the upper arm abducted 120° and the elbow flexed 90°. The subjects were asked to perform the three exercises for 5 s each. A 1-min rest period was allowed between contractions to prevent muscle fatigue. EMG data of the lumbar paraspinal muscles during the three exercises were compared using repeated-measures one-way analysis of variance (ANOVA). The statistical analyses were performed using SPSS (ver. 20.0; SPSS, IBM Corp., Armonk, NY, USA). Post hoc comparison (Bonferroni test) was conducted to examine differences among exercises. P-values <0.05 were considered to indicate statistical significance.

RESULTS

The LM/LES ratio was significantly higher in hip extension (mean \pm SD, 1.35 ± 0.39) compared with those in trunk extension (0.95 ± 0.13 ; $p < 0.05$) and during the arm lift (1.01 ± 0.49 ; $p < 0.05$). The activity level of the right LES during trunk extension (52.53 ± 16.71) was greater than those during hip extension (32.51 ± 10.91 ; $p < 0.05$) and the arm lift (14.37 ± 11.24 ; $p < 0.05$), and it was greater during hip extension than during the arm lift ($p < 0.05$). The %MVIC of the right LM during trunk extension (49.13 ± 16.27) and hip extension (41.87 ± 10.94) resulted in greater activation than the %MVIC during the arm lift (13.60 ± 9.62 ; $p < 0.05$).

DISCUSSION

This study examined selective activation of the lumbar paraspinal muscles in healthy males during various exercises in a prone position.

We observed that the LM/LES ratio during hip extension was higher than that during trunk extension and the arm lift, indicating that hip extension was more effective for selective activation of LM muscles than trunk extension or the arm lift. Additionally, the highest levels of activation in the

LM and LES were recorded during trunk extension. This result is thought to reflect increased activation of the LES during trunk extension in a prone position, as this exercise requires greater activation of the LES to lift the trunk. For stabilization of the lumbar region, many researchers have recommended lumbar extensor-strengthening exercises⁴⁾. Joseph et al.⁸⁾ indicated that the LES and LM are capable of various roles, such as prime movers or synergists working against the weight of the trunk and upper limbs, with the two muscles functioning to stabilize the pelvis with leg holding. Moreover, during the hip extension exercise, contraction of the gluteus maximus muscles generates pelvic posterior tilt torque⁹⁾, and pelvic anterior tilt torque generated by contraction of the LES to counteract the former torque would, in turn, require greater activation of the LM. During hip extension, the LM muscles function to stabilize the pelvis via their attachments to the ilia and sacrum, and this provides a stable base for the work of the gluteus maximus and hamstring, which are responsible for hip extension in the prone position. We found that hip extension resulted in the highest LM/LES ratio, indicating selective activation of the lumbar paraspinal muscles in healthy males. The results of this study indicate that, although the trunk extension exercise is recommended for activation of the LES, the hip extension exercise should be emphasized for selective activation of the LM.

This study had several limitations. First, because we used surface EMG, we were unable to consider anatomical factors in LM. An intramuscular EMG recording system could be used to target the EMG site in the LM. Second, we did not examine females. Further studies are needed to assess the effects of exercises intended for selective activation of the lumbar paraspinal muscles in healthy females.

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