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Comparison of Posterior Oblique Sling Activity during Hip Extension in the Prone Position on the Floor and on a Round Foam Roll

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Abstract. [Purpose] The aim of this study was to compare muscle activity of the posterior oblique sling during prone hip extension (PHE) on the floor and on a round foam roll. [Subjects] Twenty-two (11 male, 11 female) healthy volunteers were recruited for this study. [Methods] The participants performed PHE on the floor and on a round foam roll. Surface electromyography (EMG) was recorded from the contralateral latissimus dorsi (LD), contralateral erector spinae (ES), ipsilateral ES, ipsilateral gluteus maximus (GM), and ipsilateral biceps femoris (IBF). A paired t-test was used to compare muscle activity under the floor and round foam roll conditions. [Results] EMG activity of the contralateral LD, ipsilateral ES, and ipsilateral GM was significantly greater when PHE was performed on the round foam roll than on the floor. [Conclusion] Performing PHE on the round foam roll induced greater posterior oblique sling EMG activity than did exercise on the floor. These results suggest that the activation pattern of the posterior oblique sling during PHE is differs according to the type of surface (stable vs. unstable) on which it is performed.
Key words: Foam roll, Posterior oblique sling, Prone hip extension

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INTRODUCTION

Muscle weakness, poor neuromuscular control, and unbalanced muscle activity in the lumbopelvic region are major factors related to lumbopelvic instability[1–3]. Although it is generally accepted that both local (deep, intersegmental) and global (large, superficial) muscles contribute to the maintenance of lumbopelvic stability[4], the global muscles are primarily involved in movement and control of the spine. Specifically, global muscles transfer loads directly from the spine to the leg during movement[5]. Global muscle training is widely used to prevent and treat low-back pain[6].

Global muscle training, including trunk extension, hip flexion, and hip extension has been widely used to reduce pain and disability and improve mobility in patients with low-back pain[7, 8]. Prone hip extension (PHE) is commonly used in the rehabilitation setting to treat lumbopelvic problems[8]. The gluteus maximus (GM) plays an important role in human bipedal walking and load transfer through the hip joint; thus, weak GM muscles may result in loss of functional abilities[9]. The GM is connected to the contralateral latissimus dorsi (LD) through the thoracolumbar fascia and erector spinae (ES) muscles[10]. These muscles comprise the posterior oblique sling, which contributes to dynamic lumbopelvic stability[10]. Mooney et al.[11] demonstrated that training the posterior oblique sling muscles assisted force closure of the sacroiliac joint and stabilization of the lumbopelvic region.

An unstable surface has been shown to improve motor control and increase activity of the spine stabilizer muscles, and thus, it is often used to train lumbopelvic stability[12, 13]. Imai et al.[12] demonstrated that lumbar stabilization exercises performed on an unstable surface enhanced trunk muscle activity, and Kim et al.[13] reported that a single-leg hold exercise stimulated greater abdominal muscle activity when performed on an unstable surface than on a stable surface. Previous findings of muscle activation patterns elicited by PHE are inconsistent because the investigators focused on back and hip muscle activity and did not consider performance on unstable surfaces[14, 15]. Although several studies have demonstrated the benefit of performing trunk stability exercises on an unstable surface, few have investigated the effect of performing PHE on an unstable surface. Furthermore, no previous study has investigated the activity of the posterior oblique sling muscle during PHE performed on an unstable surface.

Thus, the present study compared posterior oblique sling activity during hip extension exercise in the prone position on the floor and on a round foam roll. We hypothesized that

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performing the exercise on the round foam roll would induce greater muscle activity than the same task performed on the floor.

SUBJECTS AND METHODS

A total of 22 healthy participants (11 male and 11 female) were recruited. The mean age of the subjects was 23.5 ± 4.92 years, mean weight was 60.4 ± 11.3 kg, and mean height was 169.72 ± 8.83 cm. Exclusion criteria were history of neuromuscular or musculoskeletal disorders, absence of normal range of movement, and leg-length discrepancy. Ethical approval was granted by the Inje University Faculty of Health Science's Human Ethics Committee. All subjects provide written informed consent prior to participation. Surface electromyography (EMG) was used to collect the raw EMG data using a Trigno wireless system (Delsys, Boston, MA, USA). The signals were amplified and band-pass filtered (20–450 Hz) before being digitally recorded at 2,000 samples/s, and the root mean square (RMS) was then calculated. Prior to the task, the subjects were asked to perform the maximum voluntary isometric contraction (MVIC) maneuver with electrodes applied to the muscle under investigation.

Surface electrodes (Trigno sensors; Delsys) were placed on the LD (4 cm below the inferior tip of the scapula and half the distance between the spine and lateral edge of the torso), ES (approximately 2 cm lateral to the L1 spinous process and aligned parallel to the spine), GM (half the distance between the greater trochanter and second sacral vertebra and on an oblique angle to or slightly above the level of the trochanter), and ipsilateral biceps femoris (IBF; 2 cm from the lateral border of the thigh and two-thirds the distance between the trochanter and the back of the knee)[16]. Skin impedance to the electric signal was reduced by shaving body hair and cleansing the skin with 70% isopropyl alcohol prior to electrode placement. For normalization, 5-s reference contraction data were recorded while subjects performed three trials of MVIC in the manual muscle testing position, as recommended by Kendall et al[17]. Three repetitions of each test were performed, with a 2-min rest period between repetitions to minimize muscle fatigue. All EMG data are expressed as percentages of the MVIC (%MVIC).

Leg dominance was determined by asking the subject to kick a ball, and the kicking leg was deemed the dominant leg[17]. The right leg was the dominant leg in all subjects. Before testing, the subjects were familiarized with the PHE position on the floor and on a round foam roll. A goniometer was used to determine when the hip joint was at 10 degrees extension with full extension of the knee joint. A target bar was placed at 10 degrees to provide feedback to the subject.

Each subject was instructed to lie prone on the floor or the round foam roll (15.2 × 91.4 cm; Sammons Preston Rolyan, Bolingbrook, IL, USA). The order of the exercise condition (floor or foam roll) was randomly determined. The subject was asked to extend the dominant leg slowly and hold it steady at the target position without loss of balance. Three trials were performed, with a 1-min rest period between trials, and the mean value of the three trials was used in the data analysis. Differences in posterior oblique sling muscle activity during PHE on the floor and that on the round foam roll were tested using paired t-tests. Statistical tests were conducted using the Statistical Package for the Social Sciences version 18 (SPSS, Inc., Chicago, IL, USA), and a p-value <0.05 was deemed statistically significant.

RESULTS

The EMG amplitudes of the contralateral LD, ipsilateral ES, and ipsilateral GM were significantly greater when PHE was performed on the round foam roll than when it was performed on the floor (Table 1).

DISCUSSION

We compared the amplitude of EMG activity in muscles involved in lumbopelvic stability during PHE exercise performed on the floor and on a round foam roll. Contralateral LD activity was assessed by comparing the relative activity levels on an unstable surface. The results supported our hypothesis that performing the PHE task on a foam roll would elicit greater activity in the posterior oblique sling muscles than performing it on a stable surface.

Ipsilateral ES and ipsilateral GM activity increased during leg extension in the prone position on the round foam roll. As a result, PHE was performed easily under the stable condition, but not under the unstable surface condition that required trunk and hip activation to stabilize the spinal column, which required greater effort to raise the leg. Our results are similar to those of Kim et al.[13], who found that when subjects were in the hook-lying position with their leg lifted, muscle activity that occurred under the unstable condition was greater than that under the stable condition. Moreover, the squat exercise performed on an unstable surface has been reported to increase trunk muscle activity compared with when performed on a stable surface[18]. These results suggest that an unstable surface may activate the lumbopelvic region and thus elicit coactivation of the global stabilizer muscles.

Compared with that on a stable surface, PHE performed on an unstable surface increased contralateral LD activity. This result is consistent with that of a previous investigation of the push-up exercise in the quadrupedal position[19].

Table 1. Activity in the muscles of the posterior oblique sling (%MVIC) during prone hip extension (N = 22)

Muscle	Mean %MVIC (SD)	
	Floor	Round foam roll
CLD	9.67 (5.43)	18.15 (7.88)*
CES	40.24 (10.22)	42.61 (11.25)
IES	32.23 (10.22)	36.61 (12.96)*
IGM	18.28 (9.32)	23.97 (11.59)*
IBF	39.12 (18.6)	35.01 (17.43)

CLD, contralateral latissimus dorsi; CES, contralateral erector spinae; IES, ipsilateral erector spinae; IGM, ipsilateral gluteus maximus; IBF, ipsilateral biceps femoris
*p<0.05

Leg extension during the push-up exercise increased activity in the contralateral lower trapezius muscle more on an unstable surface than on a stable surface. Vlemming et al.[10] described the posterior oblique sling as including the LD and contralateral GM muscle and that contraction of this muscle group tightens the thoracolumbar fascia, thereby providing lumbopelvic stability. A previous study reported that ES, internal oblique, and external oblique muscle activity showed greater improvement during a two-point stance performed with the contralateral arm and leg raised on a Swiss ball than when the same exercise was performed on a stable surface[20]. This finding may be related to the fact that the thoracolumbar fascia is connected to the internal oblique and external oblique muscles. Our results suggest that compared with using a stable surface, performing PHE on an unstable surface elicited greater activity in the ipsilateral ES and GM, rotational movement of trunk, and increased muscle activity in the contralateral LD. It is likely that contralateral LD activity was increased because this muscle controls trunk rotation during PHE on an unstable surface. Our findings are clinically relevant, as they suggest that performing lumbopelvic stabilizing exercises on an unstable surface produces greater activation of the posterior oblique sling than does performing the exercise on a stable surface. Furthermore, our results suggest that PHE performed using an unstable round foam roll promotes kinetic chain movement. This information is useful for implementing PHE exercise protocols.

Our study has several limitations. First, the subjects were healthy young volunteers; thus, our results cannot be generalized to other populations. Second, we did not measure rotation of the lumbar spine or the pelvic rotation angle, and further study is needed to examine the kinematic data for PHE.

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