J. Phys. Ther. Sci.
27: 1195–1197, 2015

Original Article

Effect of initial position on the muscle activity of the hip extensors and amount of pelvic tilt during prone hip extension

Ji-Yeon Yoon, PT, PhD[1)], Mi-Ra Lee, PT, MSc[2)], Duk-Hyun An, PT, PhD[3)*]

[1)] *Motion Analysis Laboratory, Inje University Haeundae Paik Hospital, Republic of Korea*
[2)] *Department of Physical Therapy, Wooridul Hospital, Republic of Korea*
[3)] *Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University: 197 Inje-ro, Gimhae-si, Gyeongsangnam-do 621-740, Republic of Korea*

Abstract. [Purpose] The aim of this study was to identify the effects of initial position of the hip joint with changes in the hip joint angle on the respective muscle activities of the bilateral erector spinae (ES), unilateral gluteus maximus (GM), and biceps femoris (BF) and the amount of pelvic anterior tilt during prone hip extension (PHE). [Subjects] Fifteen healthy volunteers were enrolled in this study. [Methods] The subjects performed PHE in three positions: neutral, 20°, and 45° flexed hip joint. The activities of the ES, GM, and BF were measured using surface electromyography, and kinematic values for pelvic anterior tilt were calculated using a motion capture system. [Results] There was a significant decrease in muscle activity of the contralateral ES at 45°, and an increase in the GM muscle activity and decrease in the BF muscle activity at 20°. The amount of pelvic anterior tilt was lower at 20°. [Conclusion] These results suggest that a hip flexion position of 20° would have an advantage over the other measured positions.

Key words: Electromyography, Joint position, Prone hip extension

(This article was submitted Oct. 31, 2014, and was accepted Dec. 11, 2014)

INTRODUCTION

The gluteus maximus (GM) plays a major role in functional activity as a trunk and hip extensor. Weakness of the GM could cause dysfunction in the pelvic and hip joints and back pain[1)]. Prone hip extension (PHE) is an exercise that can activate the GM effectively and is popularly used in clinics[2)]. However, unwanted substitution motion, such as pelvic anterior tilt or excessive lumbar extension, could happen during PHE due to stiffness of the hip flexor, dominance of the erector spinae (ES), weakness of the GM, and so forth[3)]. Therefore, recent studies have focused on controlling unwanted substitution motion of the pelvis and lower back during PHE[4–6)].

Joint position influences muscle contraction by changing muscle length[7)]. Many previous studies about PHE have been performed at the 0° hip flexed position[8–10)]. Some other studies have used starting positions varying from 20° to 90° hip flexion for people with hip flexor contracture[6, 7, 11)]. PHE has been performed with various interventions and positions to activate the GM. However, little information exists concerning whether hip joint angles during PHE selectively change the EMG activity of the GM. Therefore, the purpose of this study was to examine the effects of initial hip joint position on the muscle activity of the ES, GM, and biceps femoris (BF) as measured by electromyography (EMG) of the hip extensor as well as the effect of the angle of pelvic anterior tilt. Through this process, we sought the most effective position for selective GM muscle activation during PHE.

SUBJECTS AND METHODS

Fifteen healthy adults were enrolled in this study (age, 26.7±3.7 years [mean±SD]; height, 167.1±9.2 cm; mass, 58.1±11.7 kg). The right leg was the dominant leg for all subjects. Exclusion criteria were neuromuscular or musculoskeletal dysfunction of the lower back and both legs, lower back or hip pain, contracture of the hip flexor, or a hip extensor strength below fair. All subjects agreed to participate and signed an informed consent form approved by the Inje University Ethics Committee for Human Investigations. Prior to testing, 4 electrodes and 7 reflective markers were attached to the reference sites. Kinematic data of the pelvis were recorded at 100 Hz using an eight-camera Vicon MX-T20 motion capture system (Vicon Motion Systems Ltd., Oxford, UK). The respective muscle activities of the bilateral ES, unilateral GM, and biceps femoris BF were collected using a Delsys Trigno Wireless EMG system (Delsys Inc., Natick, MA, USA), which was synchronized with a Vicon Motion

*Corresponding author. Duk-Hyun An (E-mail: dhahn670208@gmail.com)

System. The EMG signals were sampled at 2,000 Hz and filtered at 20 to 450 Hz, and the root mean square values of the signals were calculated. The EMG data were expressed as a percentage relative to the maximal voluntary contraction for normalization. A newly developed two-segment model consisting of the lumbar spine and pelvis was used to measure the angle of pelvic anterior tilt. The lumbar segment was defined with four markers located on the subject's L1 and L2 spinous processes, and 1 cm lateral from the L2 spinous process on both sides. The pelvic segment was defined with three markers located on the mid-point of the posterior superior iliac spine and the bilateral anterior and superior iliac spines. Pelvic motion relative to the lumbar segment in the sagittal plane was calculated. The subjects lifted their right legs during PHE at three starting positions arranged in random order (0°, 20°, and 45° hip flexed position). With PHE at 0° hip flexion, each subject was positioned prone on a table consisting of 2 segments that were jointed in a way that it was possible to adjust the table's position so the subject's hip could be positioned at an initial hip flexion of 20° or 45°. A bar placed over the table would come in contact with the Achilles tendon when the subject's hip was extended to 30° from the initial position. EMG activities and pelvic kinematics were measured when subjects extended from their initial position. All subjects performed 3 repetitions with a 10-second rest between trials and rested for 2 minutes between each testing position. PASW Statistics for Window (ver. 18.0; SPSS Inc., Chicago, IL, USA) was used to analyze differences in muscle activities and pelvic kinematics. Repeated measures ANOVA and Bonferroni-adjusted post hoc comparisons were used to compare the respective muscle activities of the ES, GM, and BF and the amount of pelvic anterior tilt among the three initial positions. Results were considered statistically significant at $p<0.05$.

RESULTS

There were significant differences in ES, GM and BF muscle activity on the left side among the three positions during PHE. Muscle activity for the ES on the right side did not show any difference in EMG among the three positions. The amount of pelvic anterior tilt showed a significant decrease at the 20° hip flexion position compared with that at the 0° angle (Table 1).

DISCUSSION

We investigated different starting positions for selectively activating the GM during active PHE. Of the three positions, active PHE at 45° resulted in a significant decrease in muscle activity of the contralateral ES compared with the other positions. ES contraction during PHE causes unwanted pelvic anterior tilt[3]. The role of the ES as a global stabilizer was reduced at 45° because alteration of this position from the initial position to 30° hip extension induced pelvic anterior tilt. Therefore, we consider that the 45° flexed position would be able to effectively prevent excessive lumbar motion and maintain an upright pelvis alignment. However, this position did not increase GM activity. We think that the 45° hip flexed position decreased internal momentum due to the short lever arm in comparison with other positions[12].

Although the muscle activity of the contralateral ES tended to decrease at 20°, this decrease was not significant. This investigation revealed that the 20° hip flexed position needs an additional 10° hip extension for a total of 30° extension during PHE, which may result in contraction of the ES. However, this position increased GM activity compared with the other positions and decreased BF activity compared with that occurring with the 45° hip flexion angle. Additionally, the amount of pelvic anterior tilt at 20° was lower than those at 0° and 45°. We consider that the pelvic anterior tilt provided by 20° hip flexion led to the optimal length by elongation of the GM, which may contribute to increases in GM activity[12].

Previous studies have reported that muscle activity changes depend on muscle length. Worrell et al.[7] demonstrated that GM activity was greatest at the 0° angle and that HS muscle activity did not differ among all the positions they studied, which was not in line with the results of our study. They examined GM and BF activity with changes in hip and knee joint angles during maximal voluntary isometric contraction, whereas we investigated muscle activities with initial positions to 30° extensions of the hip joint during active PHE with knee extension. Chance-Larsen et al.[9] reported that restraint of pelvic anterior tilting during PHE decreased the length of the BF and influenced the synergistic relationship between the GM and BF. Of three positions, 0° could negatively impact the lumbar segment by increasing the ES activity and 45° did not activate the GM in spite of

Table 1. Normalized EMG data and amount of pelvic anterior tilt (n=15)

Variables	Hip joint position (mean±SD)		
	0°	20°	45°
Lt. ES (%MVIC)	49.5±15.3	44.1±12.4	31.7±13.2[a,b]
Rt. ES (%MVIC)	43.6±8.9	44.1±9.6	41.9±10.4
Rt. GM (%MVIC)	19.7±7.9	22.5±9.4[c]	18.9±7.8[b]
Rt. BF (%MVIC)	36.5±9.4	33.3±9.6	38.7±11.1[b]
Pelvic anterior tilt (°)	7.4±2.0	5.9±2.4[c]	7.3±2.8

BF: biceps femoris; ES: erector spinae; GM: gluteus maximus; Lt.: left;
MVIC: muscle voluntary isometric contraction; Rt.: right.
[a] Significant difference between 0° and 45° hip flexed position ($p<0.05$).
[b] Significant difference between 20° and 45° hip flexed position ($p<0.05$).
[c] Significant difference between 0° and 20° hip flexed position ($p<0.05$).

the reduction of ES activity. Hence, the 45° position could be recommended for persons who need to minimize the weight-bearing load on the lumbar spine. In conclusion, we suggest that 20° is the optimal position to activate the GM selectively by minimizing additional pelvic anterior tilt.

The present study has some limitations. First, our sample size was small, so it is difficult to generalize the findings to all subjects. Second, we examined the changes in EMG-measured muscle activity at only three joint angles; it is possible that the results do not indicate the optimal position for PHE. Therefore, further studies are needed to investigate the changes at the various PHE joint angles.

REFERENCES

1) Kendall FP, McCreary EK, Provance PG: Muscles: Testing and function with posture and pain, 5th ed. Baltimore: Lippincott Williams & Wilkins, 2005.
2) Janda V, Frank C, Liebenson C: Evaluation of muscle imbalance. In: Rehabilitation of the Spine. Baltimore: Lippincott Williams & Wilkins, 1996.
3) Sahrmann SA: Diagnosis and Treatment of Movement Impairment Syndromes. St. Louis: Mosby, 2002.
4) Hoffman SL, Johnson MB, Zou D, et al.: Effect of classification-specific treatment on lumbopelvic motion during hip rotation in people with low back pain. Man Ther, 2011, 16: 344–350. [Medline] [CrossRef]
5) Scholtes SA, Norton BJ, Lang CE, et al.: The effect of within-session instruction on lumbopelvic motion during a lower limb movement in people with and people without low back pain. Man Ther, 2010, 15: 496–501. [Medline] [CrossRef]
6) Tateuchi H, Taniguchi M, Mori N, et al.: Balance of hip and trunk muscle activity is associated with increased anterior pelvic tilt during prone hip extension. J Electromyogr Kinesiol, 2012, 22: 391–397. [Medline] [CrossRef]
7) Worrell TW, Karst G, Adamczyk D, et al.: Influence of joint position on electromyographic and torque generation during maximal voluntary isometric contractions of the hamstrings and gluteus maximus muscles. J Orthop Sports Phys Ther, 2001, 31: 730–740. [Medline] [CrossRef]
8) Arab AM, Ghamkhar L, Emami M, et al.: Altered muscular activation during prone hip extension in women with and without low back pain. Chiropr Man Therap, 2011, 19: 18. [Medline] [CrossRef]
9) Chance-Larsen K, Littlewood C, Garth A: Prone hip extension with lower abdominal hollowing improves the relative timing of gluteus maximus activation in relation to biceps femoris. Man Ther, 2010, 15: 61–65. [Medline] [CrossRef]
10) Oh JS: Effects of pelvic belt on hip extensor muscle EMG activity during prone hip extension in females with chronic low back pain. J Phys Ther Sci, 2014, 26: 1023–1024. [Medline] [CrossRef]
11) Lewis CL, Sahrmann SA: Muscle activation and movement patterns during prone hip extension exercise in women. J Athl Train, 2009, 44: 238–248. [Medline] [CrossRef]
12) Neumann D: Kinesiology of the Musculoskeletal System: Foundations for rehabilitation. St. Louis: Mosby, 2010.