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Original Article

# Activation of the gluteus medius according to load during horizontal hip abduction in a one-leg stance

Jae-Woong Lee, PT[1)], Yeong-Ju Kim, PT[1)], Hyun-Mo Koo, PT, PhD[2)*]

[1)] *Department of Physical Therapy, Graduate School of Clinical Pharmacy and Health, Kyungsung University, Republic of Korea*

[2)] *Department of Physical Therapy, College of Science, Kyungsung University: 309 Suyeong-ro, Daeyeon-dong, Namgu, Busan 608-736, Republic of Korea*

**Abstract.** [Purpose] This study researched the influences of different loads on muscle activity of the posterior fibers of the gluteus medius in a one-leg standing position. [Subjects] Twenty-four healthy adult men participated in this study. [Methods] All participants performed the one-leg standing position under four conditions: the standard no-load condition, in which the non-weight-bearing leg was lifted and kept parallel to the back and then pelvic or lumbar rotation was performed without thorax rotation, and the 0 kg, 1 kg, and 3 kg load conditions, in which horizontal shoulder abduction was performed with a load of 0 kg, 1 kg, or 3 kg added to the hand. The electromyographic activity of the posterior fibers of the gluteus medius was measured using a wireless surface electromyography under all conditions. The electromyographic activity of each muscle under the four conditions during the one-leg stance was analyzed using one-way analysis of variance. [Results] The electromyographic activity of the posterior fiber of the gluteus medius was significantly increased under the 3 kg load condition compared with the no-load, 0 kg load, and 1 kg load conditions. [Conclusion] These findings indicated that muscle activation is affected by increases in load in the one-leg standing position. The load on the upper extremity influences the muscle activity of the contralateral lower extremity.

**Key words:** Posterior fibers of the gluteus medius, Horizontal hip abduction, Load

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## INTRODUCTION

The gluteus medius muscle (GM) is the main abductor of the hip joint[1)]. The important role of the GM is maintenance of normal movement patterns of the pelvis and lower extremities[2)], and the muscle's main function is stabilization of the pelvic region against gravity when an individual is standing on one leg[3)].

Weakness of the GM causes a difference in the heights of the hip joints, which leads to lumbar pain and radiating pain[4)]. Weakness also decreases stabilization and control and is related to lower extremity dysfunction and injury[5)]. Due to dysfunction of the hip abductor muscles associated with the Trendelenburg gait pattern, pelvic instability sometimes appears as hip osteoarthritis and in patients after total knee replacement[6)]. In addition, weakness of the gluteus medius has been suggested to reduce external rotation of the hip[7)].

To strengthen the GM, Edward et al. placed resistance bands on subjects in three locations (the knee, ankle, and foot). The subjects then performed sumo walks and monster walks[8)]. Recently, rehabilitation protocols for the GM have included the slight hip flexion clam, side-lying abduction, and closed chain lateral lunges[9)]. Nelson-Wong and Callaghan have suggested that exercise strategies for patients with low back pain should focus on core stability and gluteal rehabilitation. They also suggested that muscle activation patterns and low back pain ratings change in the prolonged standing position[10)].

The one-leg stance is a necessary component in dynamic changes in body weight during walking[11)] and is a more difficult posture than double-leg standing position, because the base of support is narrower[12)]. Lifting a load with one hand causes an asymmetrical load on the body[13)]. This causes a different physical response compared with a two-handed lift and increases joint compression due to the increase in activation of the opposite GM[14)].

Therefore, this study investigated a method for strengthening the GM according to the load in the one-leg standing position.

## SUBJECTS AND METHODS

The subjects of this study were 24 healthy adult men. The mean age was 25.63 ± 3.26 years, the mean height was 173.91 ± 5.45 cm, and the mean weight was 68.33 ± 9.10 kg. Subjects were excluded if they had any musculoskeletal pathology, neurodegenerative diseases, lower-extremity injury, or pain during the past 6 months. The subjects voluntarily

*Corresponding author. Hyun-Mo Koo (E-mail: hmkoo@ks.ac.kr)

**Table 1.** Comparison of muscle activation of the posterior fibers of the gluteus medius according to load (unit: %MVIC)

| Muscle | Standard no-load condition | Horizontal shoulder abduction with 0 kg | Horizontal shoulder abduction with 1 kg | Horizontal shoulder abduction with 3 kg |
|---|---|---|---|---|
| Posterior fibers of the gluteus medius | 11.3±5.8 | 13.9±6.9 | 15.6±7.1 | 22.1±10.8 |

Mean±SD

participated in this experiment after being given an explanation of the method. All subjects checked and signed a written consent form. Ethical approval was obtained from the Kyungsung University Faculty of Health Science Human Ethics Committee.

Measurements were conducted three times, and average values were calculated. The Electromyographic (EMG) activation of the posterior fibers of the gluteus medius (PFGM) was measured by using a wireless surface EMG system (TeleMyo 2400T, Noraxon, AZ, USA). The electrode was placed 33% of the distance between the posterior ilium and the greater trochanter. The posterior ilium landmark used was 20% of the distance between the iliac crest and the L4–5 interspace[15].

In this study, the subjects in the one-leg standing position, supported themselves by placing the hand of the weight-bearing side on a table and performed 90° flexion of the trunk. The back was parallel to the ground, and the subjects faced the ground. The subjects lifted the non-weight-bearing leg and kept parallel to the back, and then they performed pelvic or lumbar rotation without thorax rotation. The standard no-load condition was horizontal shoulder abduction with no load. The subjects performed one-leg standing under four conditions: the standard no-load condition and the 0 kg, 1 kg, and 3 kg load conditions, in which horizontal shoulder abduction was performed with a load of 0 kg, 1 kg, and 3 kg added to the hand on the non-weight-bearing side. The angle of the horizontal shoulder abduction was 90°. Shoulder flexion, extension, abduction, and adduction were controlled and did not occur.

IBM SPSS Statistics version 21.0 was used to analyze the data. One-way ANOVA was used to compare the data. The percentage of maximal voluntary isometric contraction (%MVIC) was used to normalize the EMG data and was calculated with the following formula: normalized EMG (%MVIC) = EMGm/EMGmax × 100, where EMGm represents the activation of the PFGM in each condition and EMGmax represents the MVIC value for the muscle. A post hoc analysis of the four conditions was performed with Bonferroni correction.

## RESULTS

In the one-leg standing position, muscle activity around the PFGM under the standard no-load condition was 11.33 ± 5.79. When the 0 kg and 1 kg loads were added to the hand on the non-weight-bearing side with shoulder horizontal abduction, the muscle activities were 13.93 ± 6.85 and 15.63 ± 7.05, respectively. There was no significant difference between these two conditions. However, when the 3 kg load was added, the muscle activity was 22.09 ± 10.82, a significant increase compared with the three other conditions ($p<0.05$) (Table 1).

## DISCUSSION

The anterior fibers of the GM are involved in hip abduction and internal rotation and assist in flexion. The middle fibers of the GM are involved only in hip abduction, and the posterior fibers of the GM are involved in hip abduction and external rotation and assist in extension[16]. When the iliac crest on the non-weight-bearing side returns to the horizontal plane, the weight-bearing side rotates externally[17].

This study investigated a method for strengthening the PFGM. Muscle activation was compared according to load when the weight-bearing side was rotated externally in the one-leg standing position. The difference between the standard no-load condition and the 0 kg load condition was the length of the moment arm. The moment arm is the shortest distance between the axis of rotation and power, and the longer the moment arm, the more the power[17]. Neumann suggested that sit-ups with trunk lateral flexion create larger power than general sit-ups that activate the rectus abdominis because the external and internal oblique muscles create long moment arms[17]. The cross-sectional area is two times larger than that of the rectus abdominis as a result of lengthening the moment arm. However, the present study found no significant difference in the activity of the PFGM between the standard no-load condition and 0 kg load condition. This result indicates that lengthening the moment arm with shoulder horizontal abduction does not creat a long enough moment arm to influence the PFGM. The activation of the PFGM was higher under the 1 kg load condition than under the 0 kg load condition, but this result was not significant. The load transmitted to the arm was probably too small to change the PFGM. If the GM is trained in this position, then a certain amount of resistance is necessary. To maintain the load, muscle activation must increase[18]. The larger the load on the upper extremity, the more the muscles of the arm lifting the weight are activated[19]. During the one-leg stance, the EMG value for the contralateral carry position is higher when the load is 20% of the body weight compared with when it is 10% of the bodyweight[14].

In the present study, activation of the PFGM increased when the load increased. The activation for the 3 kg load was significantly increased compared with the activations for the 0 kg and 1 kg loads ($p<0.05$). Therefore, to activate the PFGM in this position, a load larger than 3 kg must be applied.

Muscular sling are groups of muscles that affect movement patterns and have an interdependent relationship with joint or neurological systems. Upper-extremity flexor sling contains the pectoralis major, anterior deltoid, and biceps. The pectoralis major and biceps also form the anterior sling with contralateral hip abductor, and sartorius[20]. Lee et al. applied a vertical load to the lower extremities during the swing phase of the gait and investigated how activation of the gluteus medius changes during the stance phase[21]. In addition, application of a proprioceptive neuromuscular facilitation pattern to the lower extremities on a single side of the body could provide an effective treatment for improving muscle activation[22]. We could increase muscle activation of a lower extremity by increasing the moment arm with a load on an upper extremity for individuals in which application of the load directly to the lower extremity is not possible.

In future studies, the relations of various positions and moment arms of the upper extremity should be considered, because only one position was examined in this study. A load larger than 3 kg should be applied in future studies. Finally, use of percentage of body weight rather than absolute weights would be more useful for generalization of the results clinically.

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