

Influence of Hip Abduction Velocity and Position on the Onset Times of Gluteus Medius and Tensor Fascia Latae Relative to Quadratus Lumborum in Healthy Subject: A Pilot Study

Jung-Bin Kim, PT, MSc • Chang-Kyo Yun, PT, MSc • Gak Hwang-Bo, PT, PhD[†]

Department of Rehabilitation Science, Graduate School, Daegu University

Received: July 14, 2016 / Revised: July 25, 2016 / Accepted: August 11, 2016

© 2016 J Korean Soc Phys Med

| Abstract |

PURPOSE: The aim of this study was to investigate the influence of hip abduction velocity and position change on the relative onset times of the gluteus medius, the tensor fascia latae, and the quadratus lumborum in healthy subjects.

METHODS: For this study, 15 healthy young adults were recruited. The subjects were asked to move their hip joints up to 35 degrees of abduction at a speed of 70°/sec and 17.5°/sec in the supine and side-lying positions. Electromyography data was collected for the gluteus medius, tensor fascia latae, and quadratus lumborum to determine the onset times.

RESULTS: There were significant differences between the fast speed (70°/sec) and the slow speed (17.5°/sec) in hip abduction in a supine position and in a side-lying position, relatively. The onset time of the gluteus medius was faster than that of the tensor fascia latae and the quadratus lumborum in the side-lying position at the speed of 70°/sec and 17.5°/sec.

CONCLUSION: The findings of this study indicated that hip abduction in a side-lying position is an effective method

to recruit the gluteus medius earlier than the tensor fascia latae and the quadratus lumborum.

Thus, the exercise position is considered necessary in the purpose of rehabilitation for gluteus medius muscle strengthening program.

Key Words: Hip abduction velocity, Position, Gluteus medius, Onset time

I. Introduction

The abductor muscle in the hip joints serves as a major muscle providing hip stability while walking and a solution to pathologic problems (Beasley, 1956). In addition, the muscle presents stability of the pelvis and external stability of the hip joints in one leg standing during which bearing three times more weight is applied to the opposite hip joint and stance phase in walking (Lyons et al., 1993). The gluteus medius (GMed) is important in maintaining a standing position and controls movement of the hip. It also stabilizes the pelvis while mobilizing the lower extremities (Hwang-Bo et al., 2016; Lee et al., 2015). Because the GMed and the quadratus lumborum (QL) are closely linked with joint support, an imbalance in muscle recruitment

[†]Corresponding Author : hbgak@daegu.ac.kr

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

patterns causes movement damage, and when the GMed is weakened, the compensation movement of the QL induces external pelvic inclination and external flexion of the lumbar to cause external instability and motor injury (Sahrmann, 2002). The weakened and contracted GMed causes habitual use including wrong movement patterns of the tensor muscle of fascia lata during hip joint abduction (Travell and Simons, 1983). Attenuation of changes in the length of the posterior GMed, and reduction and strengthening of the Tensor fascia latae (TFL) lead to muscular imbalance, as a result of which the muscle recruitment patterns of the TFL are activated faster than those of the posterior GMed in the case of hip joint abduction (Dennis and Kathryn, 2003).

The activities of the muscles are related to measurement postures and movement speed (Hodges and Richardson, 1999). Kwon and Koh (2002) reported that patients with backache showed a delay in the onset time of contraction of the gluteus maximus muscle when compared to that of the semitendinous muscle. These patients also showed a delay in the onset time of relative contraction of the backbone erectors against the semitendinous muscle (Kwon and Koh, 2002). Movement speed affects forms of motility control forms and the magnitude of the force (Vogt and Banzer, 1997). According to Hodges and Richardson (1997), in the case of muscular contraction in the flexor muscles of the upper limbs, and the trunk muscles in flexion of the shoulder joints, the onset time of muscular contraction is significantly more delayed in slow movements than in fast and normal movements (Hodges and Richardson, 1997). Such results can be explained with differences in structure and speed of the muscles consisting of fast twitch fibers and slow twitch fibers and differences in recruitment based on sizes of motor nerves. In general concentric contraction, muscular strength is more reduced as muscular contraction is faster and muscular strength is more increased as muscular contraction is slower is slower, indicating that muscular viscosity and resistance due to the viscosity

increase as speed increases (Cha et al., 1999).

There have been many researches on onset time of muscular contraction and recruitment patterns of the the gluteus maximus, the backbone erectors, and the hamstring in hip joint extension in a prone posture (Chang et al., 2006). However, Few researchers have focused on the onset time of muscular contraction relating to hip joint abduction, which causes mechanical interaction between the spine and the lower limbs and provides pelvic stability when walking. Based on published reports and clinical experience, we hypothesized that movement velocity and position is give effect to the onset time of muscular contraction. Therefore, the purpose of this study was to measure the onset time of muscular contraction of the GMed, TFL and QL in hip abduction at fast and slow speeds in the supine, and side-lying positions of normal subjects in order to compare the onset time of muscular contraction

II. Methods

1. Subjects

15 healthy young subjects were recruited from the university students who volunteered to participated in this study. The exclusion criteria were past or present neurologic, musculoskeletal, or cardiopulmonary diseases that could interfere with hip abduction (Table 1). This study was conducted in the subjects provided informed consent prior to their participation.

Table 1. General characteristics of the subjects

Characteristic	Subjects
Age (years)	21.92±2.51
Gender (male/female)	8/7 ^a
Height (cm)	170.58±5.85
Weight (kg)	62.65±14.69

Values are expressed as mean±standard deviation.

^aValues are numbers. * $p < .05$.

2. Outcome measures: Electromyography analysis for muscle onset times

We collected electromyographic (EMG) data using a data acquisition system (BIOPAC MP150WSW, Santa Barbara, USA). The subjects' skin was first cleansed with rubbing alcohol, and disposable Ag-AgCl surface electrodes were then positioned at and interelectrode distance of 2 cm. EMG data were collected as follows for the muscles on the dominant side as the lower extremity. GMed electrodes were placed parallel to the muscle fibers, over the proximal and one third of the distance between the iliac crest and the greater trochanter. TFL electrodes were placed parallel to the muscle fibers approximately 2 cm below the anterior superior iliac spine. QL electrodes were placed 4cm lateral to the vertebral ridge or belly of the erector spinae muscle, at the erector spinae muscle, and at a slightly oblique angle at half the distance between the twelfth rib and the iliac crest (Lee et al., 2014; Kasman et al., 1998). We amplified and digitized EMG signals using AcqKnowledge 3.9.1 software, with bandpass filter of (30-450 Hz) and a bandstop filters of (60 Hz), as well as sampling at 1000 Hz. The foot switch side of the popliteal region was used to determine the time (reference time: zero) of leg lifting. A plus value for onset time means later onset of muscle action than the reference time. A minus value of onset time means earlier onset of muscle action than the reference time. A period of two seconds after the start of the EMG data collection was established as the baseline period. After the EMG signals collected during the two seconds were full-wave rectified, the means and standard deviation were evaluated from the signals during the .5 of a second that was the most stable during the baseline period. Mean +2 standard deviation was established as the threshold value of the onset time of muscular contraction. The point exceeding the threshold was automatically calculated and cases of muscular contraction not longer than 25ms were not considered actual muscular contraction (Oh et al., 2006).

3. Experimental procedures

We used an electronic metronome (SEIKO QUARTZ METRONOME, SEIKO, JAPAN) and a goniometer (TSD 130B, BIOPAC System Inc. U.S.A) to control the abduction speed and angle in hip abduction. The subjects were asked to move their hip joints up to 35 degrees of abduction at a speed of 70°/sec and 17.5°/sec over .5 and 2 seconds using the electronic metronome (Chang et al., 2006). The subjects performed abduction of the right hip joint at 35 degrees in a supine and a side-lying position. To control range, a target bar was placed at the level of 35 degrees hip abduction using a goniometer, so that the side of the popliteal region on the lower extremity's dominant side touched the target during hip abduction. Before the measurement was taken, the subjects performed three practices in order to adapt to the abduction and the speed of the metronome. The order in which the exercises were performed were selected randomly. The subjects performed the exercises in all the positions using both speeds repeatedly five times, and had a three-minute rest between each measurement in order to avoid fatigue.

4. Data processing and statistical analysis

We used repeated two-way ANOVA to identifying differences in the relative onset time of the muscular contraction in the GMed, the TFL, and the QL at the fast and slow speed in a supine and side-lying position. Turkey-HSD was used for post analysis. Result of statistics, there were no interaction. The SPSS version 17.0 for Windows was used for statistical processing of the data. For all tests, the statistical significance level was $\alpha=.05$.

III. Results

The onset time of muscular contraction of the tensor fascia lata muscle of against the time of the gluteus medius muscle in hip joint abduction in a supine position was

Table 2. Relative onset time difference between each muscle and the gluteus medius

Muscle	Supine(70 ⁰ /sec)	Supine(17.5 ⁰ /sec)	Side lying(70 ⁰ /sec)	Side lying(17.5 ⁰ /sec)	p
Tensor fascia latae	-.45±.29	-1.05±.62	.14±.11	.29±.25	.02
Quadratus lumborum	-.22±.06*	-.37±.16*	.18±.13	.24±.21	.00

Values are expressed as mean±standard deviation.

* $p < .05$.

.45±.29 seconds earlier at fast speed (70⁰/sec) and 1.05±.62 seconds earlier at low speed (17.5⁰/sec). In hip joint abduction in a side lying position, the onset time of muscular contraction of the quadratus lumborum muscle against the time of the gluteus medius muscle was .18±.13 seconds delayed at fast speed and .24±.21 seconds delayed at slow speed; the onset time of muscular contraction of the tensor muscle of fascia lata was .14±.11 seconds delayed at fast speed and .29±.25 seconds delayed at slow speed.

For hip abduction in a supine position, the onset time of muscular contraction in the TFL and QL compared to the GMed onset time was earlier at the speed of 70⁰/sec and 17.5⁰/sec. In hip abduction in a side-lying position, the onset time of muscular contraction of the GMed compared to the TFL and QL times was earlier at speeds of 70⁰/sec and 17.5⁰/sec (Table 2).

IV. Discussion

This aim of this study was identify differences in patterns of muscular contraction onset and of relative muscular contraction onset in the GMed, TFL and QL in hip joint abduction at fast and slow speeds in the supine and side-lying position of normal subjects. The results showed that in the side-lying position, the muscle contraction occurred in the order GMed, TFL and QL during hip joint abduction at the fast speed, while contraction occurred in the order GMed, QL, and TFL at the slow speed. In the supine position, the TFL was the first to contract, followed by the GMed. Maximum force can be exercise in concentric contraction at slow speed, while faster contraction can

produce stronger force in eccentric movement (Wilmore and Costill, 2001). In this study, we controlled the speed of hip joint abduction as a common condition based on the research reporting that movement speed affects forms of motility control (Hodges and Richardson, 1999) and that reactions of the agonistic muscles vary in exercises with different eccentric speeds (Kulig et al., 2001). The relative onset time of muscular contraction in the QL, the TFL, and the GMed based on hip joint abduction speeds showed that there were significant differences in both positions due to the effects of the speed; changes in position also displayed significant differences at the slow speed. Hodges and Richardson (1997) reported that no differences were observed in the onset time of muscular contraction between movements at fast speed and those at slow speed in the upper limbs while reactions were delayed at slow speed. In this study, there were differences in the onset time of muscular contraction in hip joint abduction both at the fast and slow speeds, regardless of positions. Such differences may be caused by varying conditions of the upper and lower limbs. Movements of the upper limbs are wide in terms or working range. Also, angular speed is easy to maintain in these limbs, and detailed movements can be controlled because of the small muscular fibers. However, the muscles in the lower limbs are not wide in terms of working range, and it is difficult to perform uniform motion. Also, the bigger fibers in the muscles induce powerful, large movements (Horak et al., 1984).

In this study, no differences were found in the onset time of muscular contraction based on positions—supine or side-lying, but there are few previous researches to support the results. There is little previous research in

support of these results. Thus, further studies are needed to consider methods of controlling positions and accurately designing experiments. In addition, there is a need to identify the effects of exercises based on hip joint abduction speeds on the symptoms of backache and on the stabilization of the body and the pelvis in patients with backache as opposed to normal subjects. Janda (1996) also identified an abnormal recruitment sequence of hip abduction in patients compared with healthy subjects. In patients with low back pain, GMed activity was delayed, whereas GMed activity was observed before the QL and TFL in healthy subjects. The recruitment imbalance between the GMed, QL and TFL should be closely monitored for joint support and lumbar stabilization. Our results confirm the hypothesis that hip abduction in side-lying can reduce QL and TFL activity and recruit the GMed. Therefore, we suggest that hip abduction during side-lying is useful in treatment protocols designed to prevent motor control dysfunction by QL and TFL activity and facilitation the GMed.

There are some limitations in this study. Because all subjects participated in the study were young and able-bodied, our results cannot be generalized in other populations. Therefore, the benefits of hip abduction in position and velocity used in this study should be confirmed in other population of patients. Also, all participants were right side dominant and the sample size was small. In the future studies, we recommend measuring both side in the hip abduction and increasing the sample size.

V. Conclusion

The purpose of this study was identify differences in patterns of muscular contraction onset and of relative muscular contraction onset in the GMed, TFL and QL in hip joint abduction at fast and slow speeds in the supine and side-lying position of normal subjects. The findings

of this study indicated that in a two position (supine and side-lying) and two velocity (70°/sec and 17.5°/sec) is give affected GMed, TFL and the QL. Especially hip abduction in a side-lying position is an effective method to recruit the GMed earlier than the TFL and the QL. Through these results, the physical position is considered necessary in the purpose of rehabilitation for gluteus muscle strengthening program.

References

- Beasley W. Influence of method on estimates of normal knee extensor force among normal and postpolio children. *Phys Ther Rev.* 1956;36(1):21-41.
- Cha KS, Kim EH, Kim JH, et al. Exercise Prescription theory (1st ed). Korea. 21st publishing. 1999.
- Chang YJ, Ko EH, Cynn HS, et al. The effect of hip extension velocity on the relative onset time of the gluteus maximus in relation to the hamstring. *Phys Ther Korea.* 2006;13(2):70-6.
- Dennis CB, Kathryn JB. Rationale for treatment of hip abductor pain syndrome. *Iowa Orthop J.* 2003;23:57-60.
- Hodges PW, Richardson CA. Relationship between limb movement speed and associated contraction of the trunk muscles. *Ergonomics.* 1997;40(11):1220-31.
- Hodges PW, Richardson CA. Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. *Arch Phys Med Rehabil.* 1999;80(9):1005-12.
- Horak F, Esselman P, Anderson M, et al. The effects of movement velocity, mass displaced, and task certainty on associated postural adjustments made by normal and hemiplegic individuals. *J Neurol Neurosurg Psychiatry.* 1984;47(9):1020-8.
- Hwang-Bo K, Park SJ, Park BJ. The effect of hip abductor exercise on muscle strength and trunk stability after an injury of the lower extremities. *J Phys Ther Sci.*

- 2016;28(3):932-5.
- Janda V. Evaluation of muscle imbalance. Baltimore. Lippincott Williams & Wilkins. 1996.
- Kasman GS, Cram JR, Holtz J. Introduction to Surface Electromyography (2th ed). Canada. Aspen Publishers. 1998.
- Kulig K, Powers CM, Shellock FG, et al. The effects of eccentric velocity on activation of elbow flexors: evaluation by magnetic resonance imaging. *Med Sci Sports Exerc.* 2001;33(2):196-200.
- Kwon OY, Koh EK. The comparison of the onset time of hamstring, gluteus maximus, and lumbar erector spinae muscle activity during hip extension between subjects with low back pain and healthy subjects. *J Kor Soc Phys Ther.* 2002;9(2):33-42.
- Lyons K, Perry J, Gronley JK, et al. Timing and relative intensity of hip extensors and abductor muscle action during level and stair ambulation. *Phys Ther.* 1993;63(10):1598-1605.
- Lee SK, Lee SY, Jung JM. Muscle activity of the gluteus medius at different gait speeds. *J Phys Ther Sci.* 2014;26(12):1915-17.
- Lee SW, Kim SY, Yang JM, et al. Comparison of difference of the gluteus medius muscle fiber Thickness during maximum muscle contraction between Chronic Low Back Pain with Gluteus Medius Weakness and Healthy Subject. *J Korean Soc Phys Med.* 2015;10(1):71-82.
- Oh JS, Weon JH, Cynn HS, et al. Can abdominal drawing-in maneuver using a pressure biofeedback unit change muscle recruitment pattern during prone hip extension. *Phys Ther Korea.* 2006;13(4):56-63.
- Sahrmann S. Diagnosis and treatment of movement impairment syndromes (1st ed). USA. Mosby. 2001.
- Travell JG, Simons DG. Myofascial pain dysfunction the trigger point manual (1st ed). Lippincott Williams & Wilkins. 1992.
- Vogt L, Banzer W. Dynamic testing of the motor stereotype in prone hip extension from neutral position. *Clin Biomech.* 1997;12(2):122-7.
- Kenney WL, Wilmore JH, Costill DL. Physiology of sport and exercise (5th ed). USA. Human kinetics. 2011.