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Original Article

Examination of hip function and muscle activity during clam exercise

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Abstract. [Purpose] Clam exercise is commonly used to strengthen hip abductor muscles. This study aimed to classify the directions of greater trochanter movement during clam exercise and examine whether this classification reveals any differences in the characteristics of muscle activities. [Participants and Methods] Twenty healthy male participants were included and were divided into three groups according to the direction of greater trochanter movements during clam exercise: diagonally upward, backward, and upward. Muscle activity of the gluteus medius, gluteus maximus, tensor fascia lata, and external oblique was measured during clam exercise, along with the direction of greater trochanter movement and maximum muscle strength in the clam exercise limb position. [Results] In the diagonally upward group, the gluteus medius muscles showed higher activity than the other three muscles, and their activity was higher in the diagonally upward and backward groups than in the upward group. [Conclusion] The tension and action vector of the muscles changed due to differences in the direction of the greater trochanter movement caused by the movement pattern of each participant. The muscle activity around the hip joint changes with the direction of greater trochanter movement during clam exercise.

Key words: Clam exercise, Gluteus medius, Hip abduction movement

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INTRODUCTION

The hip abductor muscles play a role in the lateral stability of the lower limb and stability of the pelvis during standing and walking[1)]. The gluteus muscles tend to be weak in patients with hip joint diseases, and it is common to strengthen the hip abductors by physical therapy.

Clam exercise (CE) is one of the most popular hip abductor exercises in clinical practice[2)]. CE can be performed even in the acute stage because it requires the limb to be in a stable position, only a single joint to move, and can be performed without the use of tools or unloading[3)]. In addition, it has high versatility because the load setting is easy, and the hip abductors may be efficiently strengthened by combining hip abduction and external rotation. CE suppresses compensation of the tensor fasciae latae muscle compared to other hip abduction exercises and is recommended as an exercise to improve adductor strength[3, 4)].

Clam exercise is believed to stimulate gluteus medius muscle activity in clinical situations, but there is no collective view on this point. Previous studies have reported gluteus medius muscle activity during CE. Boren et al. reported 47% of maximum voluntary isometric contraction (MVIC), Distefano et al. reported 38% of MVIC, and Willcox and Burden reported 10–20% of MVIC during CE[5–7)]. Results regarding the ratio of muscle activity to the maximal force are inconsistent.

There are reports of changes in muscle activity in various positions of the hip and pelvis. However, there have been several studies on CE, there is no consensus regarding the efficient exercise method for CE because it is unclear whether CE itself performed well in previous studies, whether the verbal instructions were unclear, or whether individual movement patterns

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differ. The hip joint is a multiaxial joint that can move with three degrees of freedom, and it is possible that CE is affected by the movement pattern of each participant[8, 9]. Each movement pattern is reflected during CE owing to the influence of daily life activities, alignment, muscle strength, and joint range of motion. It is essential to classify movement patterns and measure muscle activity.

Currently, there are no studies that classify movement patterns during CE and examine changes in muscle activities of the hip joint. This study focused on the movement direction of the greater trochanter as a method of classifying the movement pattern during CE, as there is currently no study that subjectively classifies the movement direction of the greater trochanter by physical therapists or that examines changes in the muscle activity of the gluteus medius and other muscles. This classification method is used to evaluate Movement System Impairment[10] (MSI). Using this method, muscle activities can be clarified during CE and efficient exercises can be performed.

This study aimed to evaluate the direction of movement of the greater trochanter and to clarify the changes in muscle activity of the periarticular hip muscles according to the direction of movement.

The hypothesis was that there would be differences in muscle activity depending on the direction of movement of the greater trochanter, and that the characteristics of the direction of movement would be observed.

PARTICIPANTS AND METHODS

The participants were males without any orthopedic disease or significant limitation of the knee or hip joint or neurological disease. Exclusion criteria were: currently in pain and undergoing treatment, history of hip joint disease or femur/pelvis fracture and non-orthopedic diseases, limitation in activities of daily living, limited range of motion of the knee or hip joint. Two limds with symptoms of hip joint desease were excluded. A total of 20 participants with 38 limbs participated in this study (Table 1).

This cross-section study was reviewed and approved by the Ethics Committee of Tokyo Metropolitan University, Arakawa Campus (approval number: 19030). Written informed consent was obtained from the participants before the study was conducted.

First, the MVIC of each muscle was measured by referring to Kendall's method, and the limb position for CE was determined from previous studies as 60° hip flexion, 90° knee flexion, 0° ankle dorsiflexion, and intermediate trunk position[11, 12] (Fig. 1). The verbal instruction for CE was 'Please open your knees like a clam and do not move the hip and ankle joints'. In CE, the participant abducted and externally rotated the hip joint at any speed from the starting position to the maximum external rotation angle, performed isometric contractions for 3 seconds at the maximum external rotation angle, and then returned to the starting position at any speed (Figs. 1 and 2). Three sets of ten contractions were performed.

The muscles used for myoelectric measurement were the gluteus medius, gluteus maximus, tensor fasciae latae, and external oblique. Electrodes were attached parallel to the myofibrils of each muscle: the gluteus medius muscle, the proximal 1/3 of the line connecting the adductor magnus and the iliac crest; the gluteus maximus muscle, the 1/2 of the line connecting the adductor magnus and the sacrum; tensor fasciae latae muscle, 3 cm wide from the midpoint of the superior anterior iliac

Table 1. Participant data

	Diagonally upward group (n=19)	Backward group (n=12)	Upward group (n=7)
Age (years)	22.26 ± 0.10	22.92 ± 2.43	21.14 ± 0.35
Height (cm)	169.30 ± 4.79	170.00 ± 4.65	172.14 ± 4.97
Weight (kg)	61.34 ± 6.01	61.12 ± 4.87	65.90 ± 5.47
Muscle strength (Nm/kg)	130.52 ± 24.45*	110.39 ± 21.11*	119.65 ± 19.24

Data are expressed as the mean ± standard deviation. *$p<0.05$.
Muscle strength: Max clam exercise strength.

Fig. 1. Starting limb position during clam exercise measurement.

spine; external oblique abdominal muscle, the lower lateral part of the rib cage on the line connecting the pubic tubercle and the lower end of the rib on the opposite side.

For electromyogram measurement, a multichannel telemeter system WEB1000 (Nihon Kohden, Tokyo, Japan) was used, measured at sampling frequency of 1,000 Hz, the obtained waveform in the full wave was rectified, and the electromyogram integral value for 1 s when the electromyogram waveform was stable was calculated. The myoelectric integral value was normalized during MVIC to 100% for all muscles, and the %MVIC was calculated for each item.

The direction of movement of the greater trochanter was evaluated by another examiner. The participants were asked to perform CE with the examiner palpating the greater trochanter and were classified into three groups: (1) diagonally upward group, (2) backward group, and (3) upward group (Fig. 3).

A preliminary study, the inter-examiner reliability of the method for assessing the direction of abductor movement was examined by two examiners in ten limbs of five patients.

The maximum muscle strength was measured in the same limb position as in CE and in the limb position at 50% of the maximum external rotation angle of each participant. A manual muscle strength tester (Moby MT-100B, Sakai Medical Co., Ltd., Tokyo, Japan) was placed 5 cm proximal to the lateral epicondyle of the thigh and was fixed to the trunk and the thigh with a belt (Fig. 4). The participants performed isometric contraction for 5 s in the direction of the examiner, and the contraction was performed thrice in total with a break in between. The torque value (Nm/kg) was calculated by multiplying the obtained value by the length from the greater trochanter to the manual muscle strength tester for each participant and then dividing it by the body weight.

A two-way analysis of variance was performed to examine the changes in muscle activity between the groups during CE and the individuality of each group. A multiple-comparison method with Bonferroni adjustment was used as a post-hoc test between the levels of the factors that showed a main effect. SPSS software (version 26; IBM Corp, Armonk, NY, USA) was used for the statistical analysis, and the significance level was set at 5%.

RESULTS

There were 19 limbs in the diagonally upward group, 12 limbs in the backward group, and seven limbs in the upward group. There were no significant differences in the basic attributes of each group. The maximum muscle strength in the CE limb position of the diagonally upward group was significantly higher than that of the backward group, and there was no significant difference from the upward group (Table 1).

The inter-examiner reliability ICC (2,1) for assessing the direction of the greater trochanter movement was 0.83.

Two-way analysis of variance showed a significant difference and interaction between the direction of abductor movement and each muscle group during CE (Table 2).

Muscle activity of the gluteus medius muscle was significantly higher in the diagonally upward and backward groups than in the upward group, and muscle activity of the gluteus maximus muscle was significantly higher in the backward group than

Fig. 2. Limb position at maximum abduction and external rotation during clam exercise.

Fig. 3. Classification method of the direction of abductor movement.

Fig. 4. Limb position of measuring maximum muscle strength during clam exercise.

in the upward group (Table 3). There was no significant difference in the activities of the tensor fasciae latae and external oblique abdominal muscles between the groups.

DISCUSSION

This study investigated the activities of the hip joint muscles according to the classification of the movement direction of the greater trochanter during CE. Intergroup comparison showed that the diagonally upward group showed higher activity of the gluteus medius muscle than the upward group, and the backward group showed higher activity of the gluteus medius and gluteus maximus muscles than the upward group. These results suggest that the rate of muscle activity varies and causes indifferent greater trochanter movement.

In this study, muscle activity values for the gluteus medius and gluteus maximus muscles during CE were lower than values reported in previous studies[5, 6)]. However, comparison of muscle activity values is difficult due to factors such as EMG processing, despite normalization for MVIC. A previous study by Willcox reported similar muscle activity values of 10–20% MVIC for these muscles during CE[7)].

The hip joint has a complex structure in terms of functional anatomy and position dependency, especially regarding the position and activity of many muscles surrounding the hip joint[3)]. In this study, the diagonally upward group had higher gluteus medius muscle activity than the upward group, and the backward group had higher gluteus medius and gluteus maximus muscle activity than the upward group. The function of the hip abductor muscle group was determined by muscle fiber running and position. The length of a muscle changes when the hip joint angle changes even if it is the same muscle that affects the muscle output, and the action and exerted torque of a muscle may change because the hip joint has a high degree of freedom[13, 14)]. Muscle tension and the action vector of the muscle exerted by the difference in greater trochanter movement direction affect muscle activity.

Muscle activity changed according to the direction of movement of the greater trochanter. This may be one of the suggestions for exercise therapy guidance. In general, the focus is on observing compensatory movements, such as trunk rotation and pelvic tilt, and checking compensatory movements for the movement direction of the greater trochanter is suggested. In addition, the direction of movement of the greater trochanter may be used for verbal instructions and guidance to obtain the desired muscle contraction.

Regarding this study, it was found that the direction of abductor movement during CE affects the periarticular hip muscle activities. However, the fibers of the gluteus medius and gluteus maximus muscles were not described separately, and the function of the deep hip joint muscles remains unclear. Additionally, the study's participants were limited to healthy men, and future research should examine gender- and age-related differences in muscle activity and their relationship with hip and knee joint diseases.

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Table 2. Results of two-way analysis of variance

	Degrees of freedom	f-stop value	Significant probability
Major axis movement direction	2	6.78	0.001*
Every muscle	3	41.73	<0.001*
Reciprocal action	6	4.21	<0.0001*

Movement direction: diagonally upward group, backward group, upward group.
Every muscle: gluteus medius, gluteus maximus, tensor fasciae latae, and external oblique abdominal muscles
*p<0.05.

Table 3. Results of muscle activity (%MVIC) at clam exercise

	Diagonally upward group (n=19)	Backward group (n=12)	Upward group (n=7)
Gluteus medius	19.92 ± 20.80[1]	17.88 ± 16.48[2]	7.35 ± 12.79[1, 2]
Gluteus maximus	16.04 ± 12.69	19.16 ± 16.01[3]	12.33 ± 7.90[3]
Tensor fasciae latae	7.06 ± 7.15	5.42 ± 4.34	4.88 ± 11.02
External oblique	6.02 ± 3.03	5.31 ± 4.41	6.24 ± 5.03

Data are expressed as the median ± interquartile range.
Number: p<0.05.
1, diagonally upward >upward; 2, backward >upward; 3, backward >upward.

Conflict of interest

The authors have no conflict of interests to declare.

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