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Electromyographic Analysis of Hip Abductor Muscles during Self Training

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Key words : Hip Abductor Muscles, Electromyography, Self-Training

Abstract

The purpose of this study was to clarify differences of muscle activity by changing exercise position or load condition on hip abductor muscles, and to present the indicator for self training. Seven healthy volunteers participated in this study. All subjects performed hip abduction under 16 conditions, 1-3) 0 kg, 1.5kg and 3kg weights in lateral position, 4-6) 0 kg, 1.5kg and 3kg weights in supine position, 7-9) 0 kg, 1.5kg and 3kg weights in prone position, 10-12) 0 kg, 1.5kg and 3kg weights in standing position, 13) side stepping, 14) contralateral pelvic rise, 15) wall pushing and 16) maximum voluntary contraction. Electromyographic activity was detected during each task in the gluteus medius and the tensor fascia lata muscles using surface electrodes.

As a result, the normalized integrated EMG of gluteus medius and tensor fascia latae increased with resistant weight increase in lateral position. However, there were no significant differences between each weigh in prone, supine and standing position. In addition, the EMG activity of hip abduction at the 0 kg weight in the lateral position was the same as the activity while side stepping, wall pushing, or unilateral pelvic rising. It is consider that these results are indicators to use in programming self-training for the hip abduction.

Introduction

When the pelvis is supported by only one lower extremity, the gluteus medius muscle (GM) is important for keeping the pelvis horizontal and the gluteus minimus muscle or tensor fascia lata muscle (TFL) supports GM strongly. This stability of the pelvis is essential for normal human walking[1]. It is known that hip muscles atrophy with the progression of many kinds of hip joint diseases, and a variety of self-training exercise for hip abductor muscles are prescribed against these problems[2]. Therefore, many kinds of hip joint exercises are performed in clinical situations. For example, side stepping, wall pushing, contralateral pelvic raising and hip abduction with several weights in the lateral, supine, prone and standing positions are done to arrest muscle atrophy or to strengthen muscle contraction force.[3,4,5] However hip muscle activity during these exercises has not been clarified yet.

The purpose of this study was to describe the difference in the quantity of hip muscle activity by changing exercise position or load conditions during self training which was prescribed in a

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clinical situation for hip abductor muscles, and find indicators in the case of these prescribed exercises.

Materials and Methods

1) Subjects

7 healthy males (aged 21-33 years ; mean± standard deviation: 23.8±4.1years) participated in this study. Body weight ranged from 52kg to 70kg (62.9±6.7kg) . Informed consent was obtained from all subjects before the experiments.

2) Tasks

Task1-12: Left hip abduction was performed under the following 12 conditions, 1-3) 0 kg, 1.5kg and 3kg weights in lateral position, 4-6) 0 kg, 1.5kg and 3kg weights in supine position, 7-9) 0 kg, 1.5kg and 3kg weights in prone position, 10-12) 0 kg, 1.5kg and 3kg weights in standing position. All subjects abducted from 0° to 20°of the hip joint. It took 2 sec while abducting from 0° to 20° and 2 sec to return to the start position.

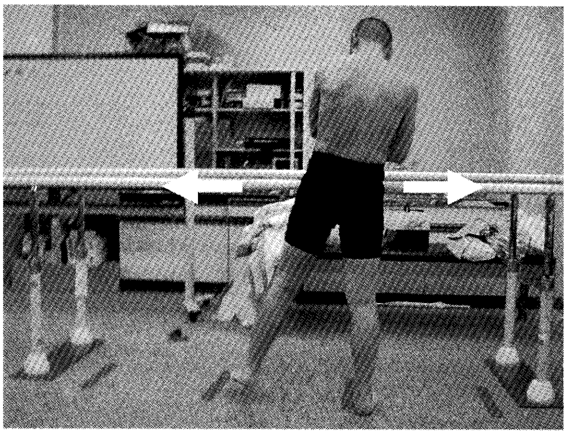

Fig.1

Task13 (Side stepping)Subjects were instructed to walk sideways. A parallel bar was set at the level of the abdomen of each subject in order to avoid trunk rotation. It took 2 sec for 1step. Subjects walked to the right side in 3 steps and to the left side in 3 steps. The stride length was 60cm (Fig. 1).

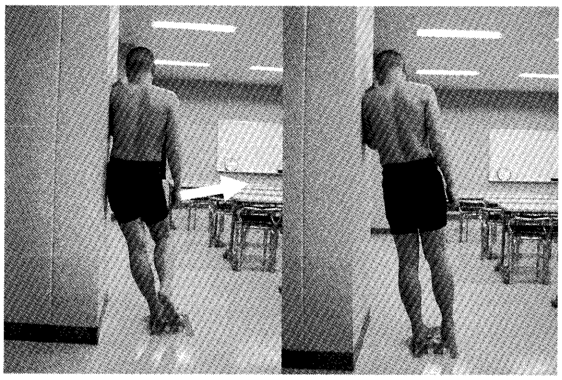

Fig. 2

Task 14 (Right pelvic rising)Subjects abducted the left hip joint from the hip adduction position to the neutral position by raising the right pelvis. When they started this motion, the left shoulder and pelvis were on the wall and only the pelvis is gradually moved away from the wall. The left foot was placed on a 5 cm stool which was 30 cm from the wall. It took for 2 sec to abduct and 2 sec to return to original position (Fig. 2).

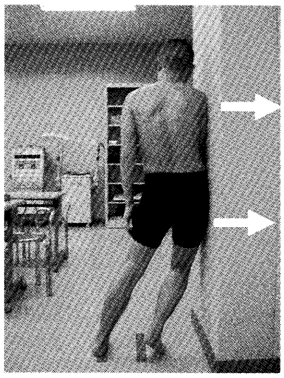

Fig. 3

Task15 (Wall pushing)Subjects pushed against a wall with their right shoulder and pelvis. The left leg was placed 50cm away from the wall. Subjects pushed against the wall for 4 sec (Fig. 3).

Task 16 (maximum voluntary contraction, MVC): Subjects were instructed to abduct their left hip joint with maximum effort to get their maximum voluntary contraction (MVC). While subjects performed this exercise, they were positioned lying on their sides, and their hip joint was in a neutral position.

Each subject practiced all these movements a few times before measurement, and checked for undesired motion. To avoid muscle fatigue, a two minute rest was allowed between each trial.

3) Data acquisition and analysis

The activity of the left side GM and TFL was measured while the above movements were performed. Bipolar adhesive surface electrodes with Ag/AgCl (disposal electrode, F Vitrode, Nihonkoden, Japan) were used to detect muscle activity. Electrodes were placed about 3 cm in front of the greater trochanter (TFL) and between the mid-illiac crest and the greater trochanter (GM). The electrode distance was set at 20 mm. A ground electrode was placed over the fibular head. The EMG signals were amplified with a differential pre-amplifier (DPA-10PB-J16, DiaMedical System, Japan) and main amplifier (BIO-TOP 6R12, NEC Co., Ltd, Japan), and were recorded with a personal computer (HITACHI) after being filtered with a bandwidth ranging from 20 to 500 Hz. The EMG signals were full-wave rectified and integrated (IEMG) by analytical software (BIMITUS). The range of analysis was set for 300msec except for 50 msec at the beginning and end for 400msec total on tasks 1-15. On task 16, that was set for 300 msec except for 100msec at the beginning and end for a 500msec total.

4) Statistical analysis

IEMG data detected during tasks 1-15 were normalized by the data detected during task 16. The statistical analysis was performed on a personal computer with statistical software (Decision of Statistical Analysis). Paired t-test, and two-way analysis of variance followed by Student-Newman-Keuls test were used to test differences by load amounts and the differences by the exercise positions. Statistical significance was set at 5%.

Results

The normalized IEMG of GM and TFL increased as the resistant weight increased in lateral positions. However, there were no significant differences between each weight in prone, supine and standing positions. The IEMGs of the GM and TFL were 29.6 % and 29.2 % maximum activity during hip abduction at 0 kg weight in lateral position; such a condition is used as "fair" in manual muscle testing. The IEMGs of GM at 0 kg and 1.5 kg in supine and prone position were significantly lower than that at 0 kg in lateral position. The IEMGs of TFL at 0 kg and 1.5kg in supine position and 0 kg in prone position were significantly lower than that at 0 kg in lateral position. The IEMGs during the closed kinetic chain tasks (side stepping, pelvis raising, wall pushing) showed no significant difference compared with the IEMG during hip abduction at 0 kg in lateral position (Table 1).

There were no significant differences between GM activity and TFL activity in lateral, prone, standing positions and closed kinetic movements. However, the IEMGs of TFL were larger than those of GM at each weight in supine position ($P<0.05$) (Table 1).

Table 1 The IEMG value of GM and TFL at all tasks.

*: significant differences against at 0 kg weight in lateral position

Position or movement	weight (kg)	GM (%)		TFL (%)
Lateral	0	29.6±14.8		29.2±9.8
	1.5	35.1±16.2		33.7±10.2
	3	42.8±19.3 *		44.8±13.8 **
supine	0	12.3±4.1 **	<	18.7±9.5 *
	1.5	14.0±4.8 *	<	20.5±9.7
	3	17.1±5.7 *	<	25.3±12.6
prone	0	14.5±7.5 *		12.3±4.7 **
	1.5	17.7±10.6*		15.6±5.0 *
	3	24.2±10.9		22.1±6.4
standing	0	25.7±8.1		21.9±6.4
	1.5	28.1±9.4		25.5±8.3
	3	32.3±10.3		31.8±11.0
side stepping (walk to right side)		25.6±12.2		22.6±7.6
side stepping (walk to left side)		22.2±11.4		20.2±8.2
wall pushing		29.8±13.0		32.4±15.7
right pelvic rising		29.7±14.1		32.5±11.5

Discussions

In this study, we clarified the EMG activities of GM and TFL during hip abduction exercise which are generally in use clinically. IEMG as reflected in compound muscle action potential, increased linearly with muscle contraction force increase[6,7]. Therefore, normalized IEMG of GM and TFL in this study reflected the contraction forces of GM and TFL. It is necessary to have 30% of MVC exercise to maintain muscle contraction force, and at least to have 60% of MVC exercise to strengthen muscles. However, subjective exercise is performed in clinical. It is very important to realize how heavy a load is best for each patient when we prescribe muscle strengthening exercises.

The IEMGs of TFL at 0 kg, 1.5kg and 3.0kg in supine position were larger than those of GM. GM has the function of abduction and internal rotation of the hip joint. On the other hand, TFL acts as an abductor, internal rotator and flexor. The friction between the foot and floor becomes the resistance force for hip abduction in the supine position. Therefore, it is considered that the IEMG of TFL were significantly larger than that of GM during hip abduction in the supine position.

There are various factors in muscle strengthening exercises such as the difference of muscle contraction pattern and the difference between OKC and CKC training. It is considered that the results in this study provide a parameter for self training in hip abduction.

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