Research in Dance and Physical Education
2020. Vol. 4, No. 3, 1-8
https://doi.org/10.26584/RDPE.2020.12.4.3.1

Unilateral Maximum Electromyography Activities When Comparing Isometric Contraction of Hip Abduction between Dominant and Non-Dominant Legs in Healthy College-aged Subjects

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The purpose of this study was to compare unilateral surface electromyography (EMG) activities of hip abductor muscles between the dominant and non-dominant leg in college-aged subjects. A total of 13 healthy participants (aged 23.3 ± 3.9 years) volunteered to participated in the study. Subjects performed three 3-second maximal voluntary isometric contractions of the gluteus medius muscle. Subjects were encouraged to maintain an isometric hip abductor contraction at full knee extension. The subjects were positioned on their sides lying on a therapeutic table. Participants were instructed to push out into the pad during each 3-second maximal voluntary isometric contraction trial. The EMG difference of a contraction in the study was evaluated during the experiments. Maximum voluntary isometric contractions of gluteus medius resulted in a significant difference between dominant (4.09 ± 2.0 volts・sec) and non-dominant (3.31 ± 2.0 volts・sec) legs during hip abductions ($p < 0.05$). The maximum peak EMG of gluteus medius demonstrated no significant difference between dominant (5.32 ± 2.0 volts) and non-dominant (5.02 ± 1.9 volts) legs during hip abductions. In conclusion, maximum voluntary isometric contractions of gluteus medius resulted in a significant difference between dominant and non-dominant legs during hip abductions.

Key word: EMG, Hip Abduction, Isometric, Strength

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Introduction

Clinician have investigated the idea of limb dominance how it related muscle functions (DeCarlo et al., 1992). In case of hip abductor muscles malfunction, this might cause a chain reaction throughout the body, creating pain and discomfort in the area of imbalance. Muscle strength and muscle endurance may be used as a criterion to assess limb symmetry (Cale et al., 2005 and DeCarlo et al., 1992). Several reliable non-weight bearing isokinetic and isometric muscular strength experiments are carried out to investigate leg muscle imbalances. Previous research study by Burnie and Brodie has indicated no isometric knee muscular strength differences between the dominant and non-dominant legs in male subjects (Burnie and Brodie, 1986). Hunter et al. (2000) observed greater dominant knee extension isometric torque than the non-dominant leg in female subjects. Previous findings from research studies of kinematic and kinetic data indicate that leg malalignment is related to inefficient neuromuscular control strategies.

EMG also has been used for assessing the tension developed in muscle or the degree of fatigue in muscle during either isometric or dynamic exercise. The EMG has proved to be a useful measure in assessing the extent of muscle activity (Petrofsky & Lin, 1980 and Petrofsky & Laymon, 2005). Under the assumption that the amplitude of the surface EMG is directly related to force, investigators have used the surface EMG to quantify activity of muscles (Hagg et al., 2000). Resistance exercise is used in rehabilitation procedures after sport injuries in an attempt to return to healthy condition (Kim et al., 2011). Resistance exercise has been shown to result in an elevation in the integrated EMG of active muscles, and this response is an important factor to examine imbalance of limb muscles (Takarada et al., 2002).

Exercise program may be modified by several factors Assessment of leg symmetry in isometric contraction with EMG readings is yet to be investigated. Dominance-related imbalance difference of the hip muscles may be responsible for the functional differences in performance, incidence, and severity of injury. The purpose of this study was to compare unilateral surface electromyography (EMG) activities of hip abduction between the dominant and non-dominant leg in healthy subjects.

Methods

Subjects

The participants in this study were volunteers from undergraduate and graduate classes at Inje University. The subjects who met the inclusion criteria of age (18-35 years), non-pregnant, no heart medication, and healthy status were recruited. Thirteen subjects (7 males, 6 females; age = 23.3±3.9

years, height = 170.5±6.2 cm, mass = 66.3±9.5 kg) volunteered to participate in the study (Table 1). The participants were screened by PAR-Q (Physical Activity Readiness Questionnaire). All of the participants signed informed consent forms to ensure the participants were knowledgeable of the risks and experiment procedures involved in this study. Subjects were excluded if they had any history of joint problems or any severe leg orthopedic injuries that prohibited participants from physical activities within the last one year. The subjects had no previous long-term asymmetrical lower extremity activity. After the informed consent and questionnaire were obtained, the dominant leg was determined by the subject deciding which foot they would select to kick a ball as far as possible.

Table 1. *General Characteristics of Subjects*

(n=13)

Variable	Mean ± SD	Min - Max
Age (years)	23.3 ± 3.9	18 - 33
Weight (kg)	66.3 ± 9.5	48.0 - 84.8
Height (cm)	170 ± 6.2	157 - 178

Values are expressed as Mean ± SD

Instruments

Electromyography (EMG) data was collected during the hip-abductor test for both dominant and non-dominant hip abductor muscles. The EMG data was measured by the BIOPAC System (BIOPAC Systems, Inc., Goleta, CA). Signals from the gluteus medius muscle were passed from the leads to the battery-operated, TEL 100M-C, which is a portable 4-channel amplifier connected by a cable to the transmission antenna. The module MP 100 converted the signal from analog to digital data. The signal then passed to the computer (Dell Optiplex GX 110) where raw EMG data was sampled and further analyzed with Acknowledge® software program (version 3.7.3, BIOPAC System, Inc, Santa Barbara, CA). Integration of EMG data was performed with the same computer. The skin was shaved and cleaned with an alcohol pad. The Ag-AgCl surface electrodes were placed over the gluteus medius muscle. To minimize movement artifact, the wires from the electrodes were taped to the skin surface and an elastic bandage was used to secure the entirety of the electrodes.

Procedures

Each subject's height, weight, and blood pressure were measured. Following a brief description of the logistics of the study, participants were led to the human performance laboratory where the experiments were applied. Participants were asked to avoid any intense lower extremity exercises twenty-four hours before the study. The subjects completed three 3-second maximal voluntary isometric contractions of the gluteus medius muscle. Recording of each trial began on the examiner's command. The examiner counted aloud following the timer from the computer every one second, and stated the sequence of each movement of the subject as a reminder. The participants were encouraged to maintain an isometric hip abductor contraction at full knee extension. The subjects were positioned on their sides lying on a therapeutic table. Participants were instructed to push out into the pad during each 3-second maximal voluntary isometric contraction trial. Before data collecting procedure began, each participant practiced several times ensure the participant's comprehension. During acquisition of the EMG signals, the examiner used markers through the BIOPAC software to mark the points at which the subject was observed to begin and end a particular motion. The EMG difference of a contraction in this study was evaluated because it was an available measurement. EMG signals were measured throughout each trial and verbal encouragement was provided during the tests. Peak and area EMG signals were collected during the experiments. Peak EMG shows the maximum amplitude value of the data samples between the endpoints of the selected area.

Statistical Analysis

The primary purpose of this study was to determine differences between the dominant and non-dominant gluteus medius in muscular voltage during maximal voluntary isometric contraction of hip abductors. Data derived from the electromyography tests were analyzed for both dominant and non-dominant hip abductors. Results were collected for each test and condition, and mean values will be calculated. The area of EMG for 3 seconds was calculated to determine comparing muscular voltage between both dominant and non-dominant extremities. The data was analyzed using SPSS 19.0 for Windows. Paired-sample T-tests were used to identify the presence of significant differences in the mean score of the three trials to assess potential differences of each performance between dominant and non-dominant legs. For this statistical test a 0.05 level of significance was used in this study. Paired sampled t-tests were used to determine if the between-group differences were significant. This was done for the anticipated and unanticipated cross cutting maneuvers for the three dimensional ankle, knee and hip kinematic and kinetic variables, ground reaction force, and EMG variables. Statistical significance was established as an alpha value <0.05. All statistical analyses were performed using PASW software (version 18.0, Chicago, IL, USA).

Results

Kinematics

To determine the difference of EMG activities between dominant (4.09 ± 2.0 volts · sec) and non-dominant (3.31 ± 2.0 volts · sec) hip abductors throughout the experiment, compared values represented the total area among the waveform and the straight line that is drawn between the endpoints during each EMG activities for 3 seconds. Maximum voluntary isometric contractions of gluteus medius resulted in a significant difference between dominant and non-dominant legs during hip abductions ($p < 0.05$). The hip abductor EMG data was reported in Table 2. Figure 1 shows the individual differences of maximum peak EMG between dominant and non-dominant hip abductors. The maximum peak EMG of gluteus medius demonstrated no significant difference between dominant (5.32 ± 2.0 volts) and non-dominant (5.02 ± 1.9 volts) legs during hip abductions.

Table 2. *EMG Level Hip Abductors*

(vol·sec)

Variable	Mean ± SD	*t* value	*p*
Dominant Leg	4.09 ± 2.0	3.44	0.005‡
Non-dominant Leg	3.31 ± 1.9		

Values are expressed as Mean ± SD.
‡Statistically signifcant difference between Donminant leg and Non-dominant leg ($p<0.01$).

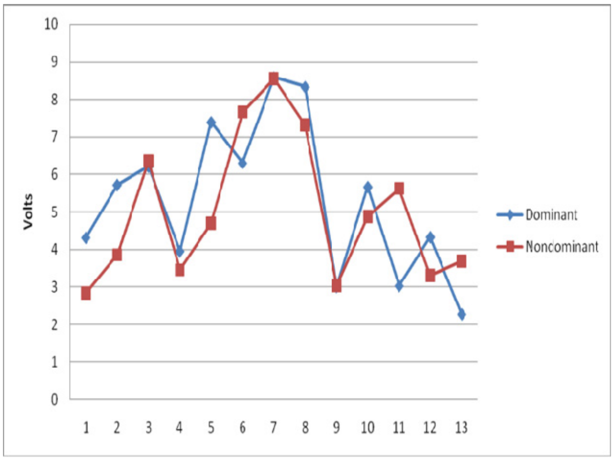

Figure 1. *Comparison EMG Peak Values between Hip Abductors*

Discussion

Surface EMG has been used in research to detect muscle activations. The purpose of this study was to compare the EMG activities of the hip abductors of the dominant and non-dominant hip muscles. The hip abductors of the dominant leg were greater iEMG than those of the non-dominant leg. Interpretation of EMG data may be the most difficult part of the muscle activities of hip abduction, but can also provide significant insight into the neuromotor controls.

Some studies have been conducted on athletes using non-weight bearing imbalance tests between dominant and non-dominant legs. Isokinetic gluteal muscles strength had revealed that no differences between the dominant and non-dominant legs in soccer athletes (Kramer, J., and Balsor, B.,1990).

Muscle imbalance of lower legs may be related to an increase risk of injury.1,14 In this study the dominant's (4.09 ± 2.0 volts・sec) and non-dominant's (3.31 ± 2.0 volts・sec) mean differences during maximum voluntary hip abduction may show imbalance of subjects in the area of EMG. The participants in this study may require an evaluation of lower leg function to decrease the risk of injury.

Even if there were mean EMG differences between the dominant leg and non-dominant leg, this study indicated no difference between dominant and non-dominant hip-abductor peak EMG. It may indicate imbalances in hip-abductor EMG are common and may not be firmly related to limb dominance. However, the EMG peak value is meaningful for averaged curves because even for smoothed rectified EMG traces, it is still too variable because of experiment interferences. The increase of EMG activity with hip abduction could have been due to limitations in EMG recordings from maximum voluntary muscle contractions.

The limitation of this study is that there were not enough subjects, and there were difficulties in differentiating the actual movements and noises of EMG signals. An advantage of surface electrode includes the ability to obtain a broad sampling of motor unit and the noninvasive nature of this technique. However, the surface EMG electrodes are susceptible to the interference of EMG signals from other adjacent muscles (Rainoldi et al., 2004). Future studies should be conducted to examine EMG signal amplitude to investigate gender differences or different types of exercise. Muscle fatigue of muscle contractile components is manifested in increased EMG activity relative to force (Tesch et al., 1990). Changes in EMG mean frequency have been used to quantify fatigability. Future studies evaluating the EMG mean frequency slope of the hip-abductor muscles between dominant and non-dominant legs should be studied to investigate muscle fatigue between dominant and non-dominant legs.

Weight-bearing strength testing should be conducted in future studies. Non-weight bearing muscular testing may not support accurate information to predict EMG muscle activities. Kramer and Balsor (1990) showed the difference in the volume of physical activity between the legs could be recorded to demonstrate side-to-side muscle imbalances.

Conclusion

This study may indicate that during the movement, it could be predicted some bilateral asymmetry exists between the dominant and non-dominant limbs, mainly due to differences in muscle imbalance between legs. The hip-abductor imbalances between legs could be related to an increase risk of injury. Dominance imbalances have been reported in injured athletes. To minimize the risk of injury, the imbalances of hip-abductor muscles should be corrected. Future studies should provide an accurate and comprehensive evaluation of EMG activity between dominant and non-dominant in different types of movement.

Acknowledgments

The outcomes of this study do not constitute endorsement of any product or exercise program by the author.

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Received: October 13, 2020
Reviewed: October 16, 2020
Accepted: October 16, 2020