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Electromyographic Analysis of Lower Extremity Lateral Stabilizer During Upper Extremity Elevation Movements

Background: This study investigated effective posture for gluteus medius rehabilitation training and effects of isometric muscle activity by electrophysiology through EMG while performing dynamic isotonic behavior of weight placed differently on upper limbs.
Method: 16 healthy male subjects 20 to 29 years of age volunteered for the study. Lateral stabilizer right gluteus medius activity was assessed using EMG while the right lower extremity maintains single limb support, and the left upper extremity elevation movement maintains 5 seconds without load, 1RM to 1 repetition, 5RM to 5 times, 10RM to 10 times, 5RM and 10RM maintain 5sec.
Results: Comparison of the mean value of EMG data showed a statistically more significant difference in upper extremity elevation movement on opposite upper extremity added weight than one that was not added on a single limb weight bearing posture($p > .05$). Weight supported side gluteus medius activity for 1RM, 5RM, 10RM weight difference and movement repetition did not differ($p > .05$). Comparison in maximum value showed statistically significant differences in not adding weight on upper limb elevation exercise and 1RM, 5RM, 10RM repeated behavior. Elevation behavior and repetition appeared over 70% of MVIC.
Conclusion: Unilateral weight bearing stance added weight in the opposite upper limb elevation movement was an indirect exercise to effectively stimulate gluteus medius activity. Applying various added weight will have effective exercise on the early stages of rehabilitation because activity gluteus medius did not differ through added weight.

Key words: *Gluteus Medius; Repetition Maximum; Electromyography*

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INTRODUCTION

The primary role of gluteus medius(GM) is to stabilize the pelvis and control femoral motion during dynamic lower extremity motion(1, 2, 3). Three distinct portions of the GM have been identified based on anatomical arrangement and differing activation patterns. The posterior portion functions to stabilize the hip joint, the middle portion to abduct the hip, and the anterior portion to internally rotate the hip(4). The GM muscle is a primary abductor of the hip and is an important pelvic stabilizer during walking and other functional activities(5).

Altered activation of the GM has been associated with several lower extremity injuries(2, 6). Clinically, dysfunction of GM has been implicated in numerous musculoskeletal disorders including lower back pain, patellofemoral pain syndrome and numerous other lower limb injuries(7, 8, 9). Therefore, it may be helpful to include functional training of the GM into the rehabilitation program(1).

Weight-bearing strengthening exercises have been shown to produce significantly higher GM activity in comparison to non weight-bearing exercises(10, 11, 12).

Kim et al. reported the most effective amount of resistance needs to measure before therapeutic resistive exercise plan for rehabilitation(13). In light of previous studies for resistance quantity examine, strength increases when 3 sets of isotonic training program at 3 weeks 6RM(repetition maximus) to 3 times a week was implemented, and even without 6 weeks of special training, large decrease in strength did not happen. Since then, strength improved when the load of 1RM and 1 set was carried out 1 time a week for 6 weeks(14). The increase in strength appeared in maximum effect in 3 sets to 6RM(15).

Horak et al. asserted that hamstring did earlier contraction than anterior deltoid at fast upper flexion exercise extremity(16). Lee et al. reported knee flexor and erector spinae muscle activity increases significantly while starting movement of upper extremity or moving(17). Adversely, EMG test result of biceps brachii during lower exercise had results of the study with happening cocontraction(18). This is when effects of exercising a part of the body will be explained by electrophysiology transition effect to pass on to other parts of the body.

In this study, in order to provide variety and effective rehabilitation programs for changed GM after the lower extremity injury, effective posture of GM stimulation is investigated, and activity effect of lower extremity stabilizer investigate for electrophysiology transition effect through EMG during dynamic isotonic behavior with weight difference on upper extremity.

MATERIALS AND METHODS

Participants

Subjects were aware of the purpose of the study and 16 patients volunteered. They were 20 years old and above male college students, who were healthy people with lower extremity or back injury and had never received treatment during the last 6 months. The general characteristics of the subjects are shown in Table 1.

Table 1. Subjects profile

Characteristic	Age(years) Mean±SD	Height(cm) Mean±SD	Weight(kg) Mean±SD
N=16	23.60±.66	173.65±4.39	68.03±6.94

Procedures

Lower extremity movement is support to right single limb with left knee joint and hip joint 90° flexion without support situation for improving GM activity of static contraction. Upper extremity movement is composed for maintenance and repetition of left arm elevation movement for GM activity through indirect stimulus. For maintaining right single limb support, right hip abductor has to produce abduction torque to stabilize the pelvis at frontal plan about weight and body attached to the load caused by the adduction torque. Upper extremities constructed considering distribution of the mass of lower extremity segmentation on characteristics, movement performed shoulder abduction to elbow extension of left upper extremity considering mechanical characteristics of inner torque can increase gravity, moment of inertia, lever length and posture strategy(19). 1 time not repeat the behavior to hold for 5 seconds in the shoulder 90° and repeated without maintain 90° elevation repeat behavior. In addition to the weight of the upper extremity set bare hands, 1RM, 5RM, 10RM.

1RM, 5RM and 10RM for upper extremity elevation exercise will be predicted from the Oddvar Holten diagram(20)(Fig. 1), and 1RM can be computed by the formula(Fig. 2).

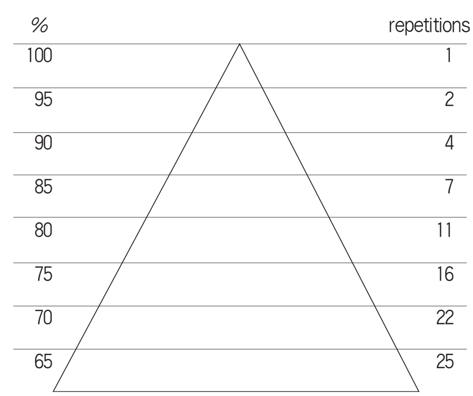

Fig. 1. Oddvar Holten diagram

$$\frac{\text{Akg} \times 100\%}{\text{B}\%} = 1\ \text{RM}$$

Fig. 2. A: lifted weight, B: percentage of intensity

Elevation movement of arm was carried out by separating bare hands without weight maintenance time for 5 seconds(0-1), 1RM weight of 1time repeated(1-1), 5RM weight of 5 times repeated(5-5), 10RM weight of 10times repeated(10-10), 5RM weight of 1time 5 seconds maintenance(5-1) and 10RM weight of 1time 5 seconds maintenance(10-1).

Electromyography

Before entering the experiment, we practiced enough so that the experimental situation and motion were familiarized by themselves. After conducting these practices, we measured the experiment. First, to set up the standard of comparison for activation of the GM muscle, maximum voluntary isometric contraction(MVIC) tests were carried out. Positions for the MVIC testing were chosen based on commonly used positions for manual muscle testing and MVIC measurements. Maximum-effort hip abduction, performed in a side-lying position with 25° of hip abduction, was used to test the MVIC for the GM(21). Subjects performed 1 practice trial, to ensure that they understood the task, and received standardized verbal encouragement during all MVIC trials to help them produce maximal effort. EMG data that each action performed by every action 5 times was collected. During the experiment, reducing fatigue of the subjects and believed to be accurate in operation, every 5 minutes of break was placed for data collection. To get quality EMG data alcohol was used after washing the skin surface and a razor was also used to remove hair of cutaneous layer. Two pole surface electrodes were attached at 1cm intervals along the muscle fibers to the direction of travel at gluteus muscle belly of subjects and ground electrode was attached at the lumbar 5. EMG measurements was measured every 10 seconds with pottery wireless EMG(ME6000T8, Mega electrode Ltd, Finland) and 1000Hz sampling frequency was set to collect the data. To determine behavior characteristics of the process in conjunction with EMG data, installing video camera(NV-GS 250, Panasonic, Japan) and subjects face to face, by shooting at a rate of 30 frame/sec collects data in conjunction with EMG meter. EMG data using the associated video data, flexion to 90° left knee and hip, right single limb support, starting left upper from elbow extension to shoulder abduction, after 90° abduction to returning start point divided into section, making the TXT file from EMG raw data, using analysis program (SIMI Motion ver 7.3, SIMI Reality Germany). It was filtered by usable energy range to 50-500Hz band-pass of EMG signal(22). After filtering materials is full wave rectification, the rectified EMG values using cutout frequency 4Hz filtered lower-pass(Fig. 3). The reason the low-pass filter is used would have very similar to characteristics with the graph indicated strength of the muscle; linear envelope obtained by filtering a lowpass filter(23).

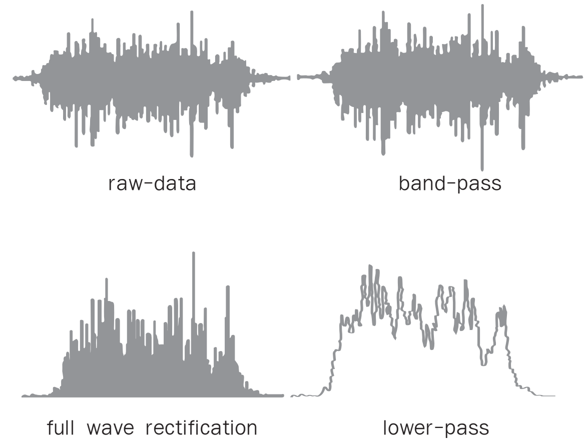

Fig. 3. EMG data processing

Statistical Analysis

Average value and maximum value was measured at each motion. An analysis program was used and then average and standard deviation output, to verify the average value of gluteus action potentials each motion and max average value of difference was used by SPSS(ver. 10.1) statistical program and one-way ANOVA with practices set-up at the significance level of α=.05.

If there is significant difference between the motion, Duncan law of the post-mortem(Post hoc) was tested for investigating different groups.

RESULTS

While maintaining a step with static contraction of right gluteus, difference to the maximum number of the left upper limb of the dynamic elevation motion that EMG data average of the right gluteus average and standard deviation of the maxium value is as same as Table 2. Normalization by MVIC was not practiced because of comparison of the same subjects to the same muscle.

Table 2. Average and max descriptive(μV)

	N	Average Mean±SD	Max Mean±SD
0-1	16	73.52±46.59	336.48±228.95
1-1	16	137.28±74.14	603.43±309.40
5-5	16	137.92±64.06	748.17±412.78
10-10	16	131.57±63.32	787.75±440.58
5-1	16	128.40±75.52	575.92±320.13
10-1	16	119.97±57.32	565.86±284.54

Maximum number of repetition varies and to compare the difference gluteus activation of the right leg which maintains single support position during performance of the left upper limb elevation motion presented no significant difference between the behavior(p〉.05) from compared result average value of obtained gluteus EMG data. Post-test to examine the difference for the behavior is classified into different groups that is just between not impose weight(0-1) and impose weight. There was no difference between the iterations imposed weight groups(1-1, 5-5, 10-10) and 5 seconds maintained groups(5-1, 10-1).

Table 3. Average oneway ANOVA(p〉.05)

	Sum of square	df	Mean square	F	Significance
Between groups	47609.783	5	9521.957	2.306	.051
Within groups	371576.380	90	4128.626		
Total	419186.163	95			

With varying maximum number of iterations, during the operation, the left upper limb elevation, to compare the difference in the activity gluteus of right leg at maintained single support phase. According to compared results, obtained gluteus EMG data of maximum value, presents no significant difference between the behavior(p〉.05). To examine the difference for the behavior in the post-test, it was classified as different groups between not impose motion(0-1) and imposed by the weight of repeated behavior(1-1, 5-5, 10-10).

Table 4. Average post hoc tests(Duncan)

Movement	N	Subset for alpha = .05 1	2
0-1	16	73.52	
10-1	16		119.97
5-1	16		128.40
10-10	16		131.57
1-1	16		137.28
5-5	16		137.92
Significance		1.000	.467

Table 5. Max oneway ANOVA(p〉.05)

	Sum of squares	df	Mean square	F	Significance
Between groups	2053561.636	5	410712.327	3.540	.006
Within groups	10440672.497	90	116007.472		
Total	12494234.133	95			

Table 6. Max post hoc tests(Duncan)

Movement	N	Subset for alpha = .05 1	2
0-1	16	336.48	
10-1	16	565.86	565.86
5-1	16	575.92	575.92
1-1	16		603.43
5-5	16		748.17
10-10	16		787.75
Significance		.062	.104

In comparison with EMG maximum value between average value comparison and the added weight of repeated motion is classified in the same group. In the case of the added weight with 5 seconds maintained motion(5-1, 10-10), it seems to be compared that 5 seconds maintained motion of without added weight group(0-1) and repeated by added weight groups(5-5, 10-10) contains all of the other.

Proportion of average and maximum value of gluteus EMG data is same following figure 4, 5 in MVIC of gluteus. Heyward asserts that 70% of MVIC gluteus was proposed as a baseline comparison for comparison to 70-85% of MVIC exercise intensity which prescribed for purpose of hypertrophy aspects for develop strength and muscular endurance(2, 4).

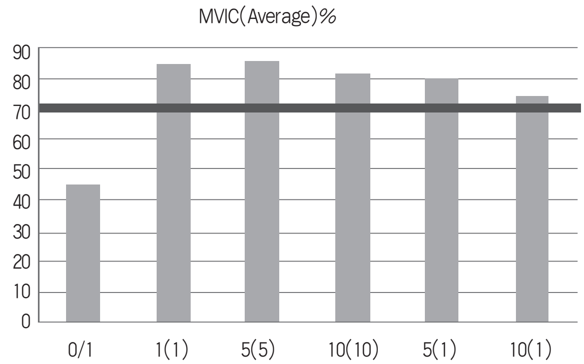

Fig. 4. Average MVIC

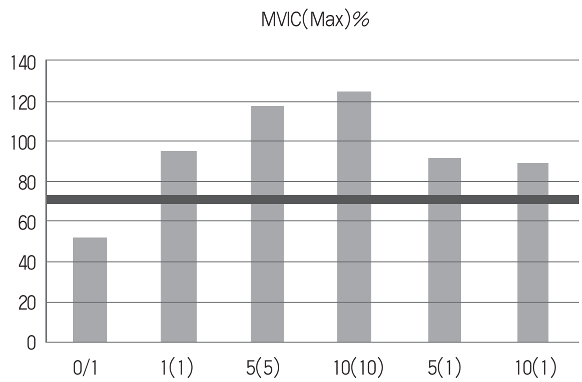

Fig. 5. Max MVIC

DISCUSSION

GM weakness has been associated with several lower extremity injuries, including patellofemoral pain syndrome(25, 26, 27). Weakness of the GM and maximus may contribute to lower extremity injury by influencing joint-loading patterns and lower extremity control(28, 29). As the gluteal muscles resist these possibly injurious motions, improving gluteal muscle strength and activation may be a critical aspect of rehabilitation and injury prevention programs(8, 30). Therefore, in this study rehabilitation perspectives evaluated ways that are versatile and efficient to GM.

While maintaining the single limb support posture that is required, most of the power for hip joint is produced by the GM of the hip abductor(31). The static single-leg stance exercise with transverse plane loading has been shown to activate the GM(3). In this study, aspects of these dynamics are considered and selective activation of GM to the basic position for the right single limb support were studied.

Looking at previous studies, it has been reported that during an upper extremity exercise, the trunk or lower extremity muscles are simultaneously activated(16, 17). Therefore, while maintaining the right single limb support which the additional active stimulus for GM, 5 seconds to keep the movement weight that was added on the left arm is maintained and movement of maximum repetitively was separated in parallel. As a result, the cases that the weight attached to the arm lift movement and not attached showed statistically significant differences in comparison to the mean value of the EMG data of GM(p>.05). In comparing the maximum, cases that only maximally repeat RM and not attached showed statistically significant difference(p>.05). While case of maintaining upper extremity for 5 seconds did not show significant differences that case of attached weight and not attached. As a result, single limb support attached to the arm elevation movement showed that GM where side of weight bearing can be effectively activated.

In general, it is known that the best suitable maximum repetition is between 3RM and 9RM(32). Results for 3 times per week over a period of nine weeks, 6-8RM 3 sets increased by 20% of maximal strength(33). In this experiment, 1RM, 5RM, 10RM set 5 seconds between each maximal repetition that upper arm elevation movements are charged according to the single limb difference in the maximum number of iterations to determine whether differences in activity was performed in maintaining or up. However, in comparing the average value of GM activity, neither RM weight maintenance nor repeated movement showed any difference(p>.05). In comparing the maximum value, exercise that did not add weight and repeat movement attached by the weight was different(p>.05).

Earl compared to activities of GM in the single limb supported by two kinds of resistance(1). As a result, 2.26kg was larger than the activity with 4.53kg. Therefore, a significant difference was seen between the two weights. For this experiment, the load is applied directly to the GM to be tested by the experimental design. A significant difference in the weight difference that could not be verified was considered because in this study, upper extremity applied weights were applied indirectly, adding to the weight load on the GM to the experimental design and experimented.

In Schott et al. study, lateral lower extremity maintained continuous isometric exercise that 70% strength of maximal voluntary contraction(34). As a result, intermittent exercise programs applying right leg higher effects were reported. Also adaptation was reported for the stimuli because changes were significant. Phosphate metabolism and pH of continuous contraction were applied to lower extremities. In this study, while maintaining or repeating upper limb elevation motion with the added weight, most of the EMG activity values of the GM were more than 70% of MVIC values(Fig. 5, 6). Indirectly, GM muscle activity has been activated following a movement with load of the upper extremity. That should be incorporated into the rehabilitation plan to increase GM strength. In general, the isometric exercise increases muscular endurance(35). Strength and muscular endurance increased by isometric program that is effectiveness in the specific joint angle and raining a muscle group(36). This is pointed out as shortcomings. Therefore, in the rehabilitation program to increase GM isometric active, GM muscle activity has been activated following a movement with load of the upper extremity that can be applied to early rehabilitation without regard to the mechanical properties of weight and the number of repetitions of various weights.

CONCLUSION

In this study, by finding how upper extremity with added load influences GM activity on one-leg standing position, we provide fundamental data of rehabilitation training on GM activity stimulation method. Single limb support and upper extremity with added load were indicated most effective on GM activity.

Thus, by adding load to upper extremity to form a part of variety method to simulate GM from rehabilitation early stage, it is likely to vitalize GM selectively through indirect stimulation. On the other hand, large difference on GM activity from distinction of weight is not provided, so in order to get more effective outcome for distinction of weight, it is necessary to examine in three-dimension from a physiological and mechanical aspect.

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