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The Effects of Changes in Upper Limb Loads on the Activity of the Gluteus Medius Muscle in Single Limb Support

The purpose of this study is to find out the activity of gluteus medius muscle by the changes of load given to the upper limbs in single support phase. This study was twenty healthy men from A College. The left gluteus medius muscle was measured using SEMG(surface Electromyogram). Only the left foot was supported, and for the right foot, the right upper limbs were abducted while hip joint and the knee joint were bent at a 90° angle. The study was made by giving weight using dumbbells, depending on the RM of the subject(0RM, 1RM, 3RM, 5RM, 7RM). Gluteus medius muscle showed a large activity for those given weight to the upper limbs(1RM, 3RM, 5RM, 7RM) than that without weight(0RM). There was a significant difference in the activity of gluteus medius muscle between each RM. Gluteus medius muscle is high active when weight is given to the upper limbs in single support phase.

Key words: *Gluteus Medius, Arm Load Quantity, RM, SEMG, Single-Leg Stance*

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INTRODUCTION

Balance is an ability to have major effects on the performance of all activities in daily living to maintain the body in equilibrium(1, 2). Balance is a complex motor control work that include the integration of sensory information, processing by the nervous system, and biomechanical factors(3). Three functional elements, that is, support by the musculoskeletal system which is the biomechanical aspect of the body, motor functions including motor coordination, and integrated actions of sensory functions are necessary for normal balance responses to occur(4). The body can maintain balance only when internal force(muscle contraction, etc.) acts against postural changes caused by external forces(gravity, inertia, ground reaction forces, etc.)(5).

The gluteus medius muscle is a representative hip joint abductor muscle and is an important antigravity muscle. This is a fan-shaped muscle extending from the crista iliaca of the pelvis to the greater trochanter of the femur which beings to contract at the end stage of the swing phase, contracts maximally during the mid stance phase. It contracts efferently to prevent the pelvis from dropping during the swing phase(6). If the gluteus medius muscle is week or the beginning of hip joint abduction movements is suppressed, hip hiking deformation will occur. Therefore, if the gluteus medius muscle is weakened or suppressed, walking will be damaged or restricted(7). Patients with weak gluteus medius muscles cannot maintain pelvic stability, become to have problems in walking as a results, and gradually develop low back pain, buttock pain, and greater trochanter bursitis, etc. When the low back pain of females with weak gluteus medius muscles was identified through physical tests and the weak gluteus medius muscles were treated with appropriate rehabilitation programs, the pain of patients with weak gluteus medius muscles was gradually relieved(8). The gluteus medius muscle is maximally activated when the hip joint is abducted or internally rotated. The gluteus medius muscle's isotonic abduction and internal rotation movements in single limb support are very effective in the early stage of neuromuscular rehabilitation. Therefore, those movements should be made very importantly in the early stage of rehabilitation and rotation and functional movement patterns should be added to the hip joint(9).

In many previous studies, tasks to lift the upper limb were given to patients and resistance was given to the upper limb or the velocity and direction of movements were changed(10). These studies showed that the muscle contraction caused by the movements of the upper limb quickly induced muscle contraction to the proximal and distal parts of the lower limb(11).

In single limb support, the activity of posture maintaining muscles such as the gluteus medius muscle and the triceps surae muscle becomes higher than in double limb support(12). In single limb support, during abduction movements with a certain load(3㎏) given to the upper limb, the hip joint abduction muscle(the gluteus medius muscle) showed the highest activity on average(13). However, studies in which different amounts of loads(1RM, 3RM, 5RM. 7RM) were applied to the upper limb to examine the activity of the gluteus medius muscle activity are insufficient.

Therefore, the present study was conducted to identify the activity of the gluteus medius muscle with different amounts of loads on the upper limb and present grounds for gluteus medius muscle related rehabilitation in clinics.

METHODS

Subjects

The subjects of the present study were 20 male adults who voluntarily participated in the present study, understood the purpose and intent of the present study, had no neurosurgical or orthopedic disorders, and were right handed. The subjects' physical characteristics are as shown in Table 1.

Table 1. Characteristics of the subjects

Division	Age(yrs)	Height(㎝)	Weight(㎏)
n=20	25.75±2.64	175.19±3.27	67.25±5.92

Experimental Apparatuses

In the present study, to examine the activity of the left gluteus medius muscle in left lower limb support, experiments were conducted through surface electromyograms(SEMG) at different amounts of loads imposed on the upper limb. ME6000 was used for EMG(SEMG) and 1RM, 5RM, and 10RM Dumbbells were used.

Study Procedure

Electromyography

MegaWin version 2.3a was used as a computerized SEMG measuring instrument and an SEMG analyzing program and EMG measuring equipment connected to a PC were also connected to the main body. Anthropometric data such as the subjects' heights and weights necessary for the program were measured and electrodes were prepared to attach them to muscles selected in advance. Body hair was removed to minimize noises and the skin was gently wiped off using alcohol to prevent oil stains or lotion from remaining on the skin.

Two each of surface electrodes were attached to 2cm above and below the 1/2 point on the line on the left gluteus medius muscle connecting between the anterior superior iliac spine and the greater trochanter of the hip joint(14).

Experimental procedure

In an upright standing posture facing forward without any weight in hands, the experimental subject conducted 90° flexion of the hip joint and knee joint of his right lower limb along with a oral order "Start", performed upper limb abduction(0~90°) in left lower limb support, and returned to the original state(double limb support). For consistency of the experiment, the foregoing movements were performed three times repeatedly. Loads were imposed with 0RM, 1RM, 3RM, 5RM, and 7RM dumbbells respectively and the foregoing experimental procedure was followed. The RM was measured according to Holten Diagram.

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

A: dumbbell weight
B: % according to Holten diagram

The laboratory was maintained quiet and warm and the subjects wore casual clothes. The experiment was conducted slowly without hurrying up and the foregoing movements were made after sufficient. SEMG measurement began from the double limb support before the upper limb movement and continued until the time when the weight was completely distributed evenly to both lower limbs after the practice of upper limb movements.

Data Analysis

The activity of the gluteus medius muscl at different upper limb weight load amounts(0RM, 1RM, 3RM, 5RM, 7RM) was analyzed through one way-ANOVA using the SPSS program. Post hoc analysis were performed using least significant difference (LSD). The statistical significance level was set to 0.05.

RESULTS

The Effects of Changes in Upper Limb Load Amounts on the Activity of the Gluteus Medius Muscle in Single Limb Support

The averages of the activity of the gluteus medius muscle in relation to 90° abduction movements of the upper limb were compared and the results showed the highest activity at 7RM repetition. The averages of the 20 subjects were 84.25±32.51㎶ at 0RM, 243.57±103.48㎶ at 1RM, 231.54±112.26㎶ at 3RM, 315.94±120.57㎶ at 5RM, and 324.67±114.24㎶ at 7RM repetition(Table 2).

Post-hoc tests were conducted and 1RM, 3RM, 5RM, and 7RM showed statistically significant differences compared to 0RM($p<.05$), and 1RM, 3RM, and 7RM showed statistically significant differences compared to 5RM($p<.05$).

Table 2. Averages of the activity of the gluteus medius muscle at different upper limb load amounts in single limb support

	0RM[a]	1RM[b]	3RM[c]	5RM[d]	7RM[e]	p
EMG(㎶)	84.25±32.51	231.54±112.26	243.57±103.48	315.94±120.57	324.67±114.24	.000
post-hoc	: b, c, d, e	: a, d, e	: a, d, e	: a, b, c, e	: a, b, c, d	

DISCUSSION

Human postural and balance control is performed through integrated information from the visual system, the vestibular system, and the somatesthesia system(15). The somatesthesia system provides proprioception information and motor information through the Plamtecutaneous mechanoreceptors, joint sensory receptors and muscle sensory receptors(16).

Laura et al. advised that wider basal areas were more helpful to stability(17). Since the activity of posture maintaining muscles becomes higher in double limb support than in single limb support(12) and requires the integration of the sensory system, the ability to achieve balance in single limb support was examined. A study compared the activity of the gluteus medius muscle in single limb support with two levels of resistance(2.26㎏ and 4.53㎏)(9). In the present study, maximum loads(RM; 0RM ,1RM, 3RM, 5RM, 7RM) were applied to the upper limb to give radiative resistance when the activity of the gluteus medius muscle was compared. In a study conducted by Cale et al, the results of EMG of the muscle activity of superior and inferior hip joint abduction muscles did not show significant differences with 81.0±23.7㎶ for the superior muscle and 76.1±9.9㎶ for the inferior muscle($p>.05$)(18). Therefore, an experiment was conducted where all the subjects performed 90° abduction with 90° flexion of the hip joint and the knee joint of the right lower limb in left limb support.

In the present study, it could be seen that when body balance was lost at the maximum load(RM) of the upper limb in single limb support, the gluteus medius muscle was activated for postural control. This result supports the theory indicating that in single limb support, hip joint stability is solely achieved by the supporting side hip joint abduction muscle(19). In single limb support, the activity of the gluteus medius muscle showed significant differences between different maximum upper limb load amounts(RM)($p<.05$). This result supports the theory indicating that, during weight bearing isometric movements leaned toward five directions, the results of EMG of all four muscles; the gluteus maximus, the gluteus medius muscle, the vastus medialis, and the biceps femoris muscle show high activity of all the four muscle(20).

Neumann measured SEMG of the muscles around the hip joint in relation to upper limb movements and the results showed higher muscle activity when weight loads were imposed on the upper limb in single limb support with 35.5±20.6㎶ at 90° shoulder joint abduction and 42.2±22.1㎶ at 90° shoulder joint abduction with a 3kg dumbbell in the hand. Jennifer compared the activity of the gluteus medius muscle between two levels of resistance(2.26㎏ and 4.53㎏) in single limb support and the two weights showed a significant difference with higher activity at 4.53㎏ compared to 2.26㎏($p<.05$)(13).

The results of the present study showed an average activity of 84.25±32.51㎶ at 0RM with no upper limb maximum load(RM), 243.57±103.48㎶ at 1RM, 231.54±112.26㎶ at 3RM, 315.94±120.57㎶ at 5RM, and 324.67±114.24㎶ at 7RM repetition. This means that the larger the load imposed on the upper limb, the higher the activity of the gluteus medius muscle. Bae et al. said that the most effective amount of resistance should be measured before planning therapeutic resistance exercises(21).

Mun conducted kinetic analysis of the lower limb in relation to changes in gait velocity and analyzed the EMG of muscle activity(22). Kim et al. conducted kinematic and kinetic comparison and analysis of stair climbing and flatland walking(23). Jeon analyzed the EMG of the agonist of dancing motion pull up(24) and Oh JS studied the effects of hip joint internal rotation during stair climbing and descending on the activity of the quadriceps femoris muscle and the gluteus medius muscle(25). As mentioned above, many studies have been conducted on the effects of walking, stair climbing, or running on the activity of lower limb muscles. Although such exercises are also effective, this author thinks that the levels of activity at individual maximum repetitions(RM) used in the present experiment can be usefully used when the gluteus medius muscle that greatly affects lower limb stability should be intensively strengthened. In addition, the results indicating that the most effective maximum load(RM) for the activity of the gluteus medius muscle is 7RM can contribute to the planning of exercise programs for general public or patients with insufficient hip joint stability.

In later studies, the open-chain and closed-chain postures of the gluteus medius muscle should be compared and analyzed, muscle strength improvement, postural control, and balance using Biofeedback systems should be studied, and not only EMG analysis but also studies of the force and moment occurred during movements using force plates and the changed center of gravity should be conducted.

CONCLUSION

The present study was conducted with 20 male adults in their 20s in Gwangju Health College in order to examine changes in the activity of the gluteus medius muscle according to changes in weight on the upper limb among 0RM, 1RM, 5RM, 10RM, 5M repetition, and 10RM repetition.

SEMG was used to measure the activity of the gluteus medius muscle. In the experiment, the activity of the gluteus medius muscle on the weight bearing side during 90° abduction of the right upper limb with 90° flexion of the hip joint and the knee joint of the right lower limb in left lower limb support was measured when the subject was in a standing position facing forward.

The levels of the activity of the gluteus medius muscle at all maximum repetitions(RM) were analyzed and according to the results, all the subjects showed higher activity at 1RM, 3RM, 5RM, or 7RM than at 0RM. They showed higher activity at 7RM repetition than at other maximum repetitions(RM).

From the results of the present study, it can be seen that having the gluteus medius muscle move while increasing loads on the upper limb is more effective that activating the gluteus medius muscle at 0RM and that, among others, 7RM strengthens the gluteus medius muscle the most efficiently and contributes to stability.

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