

# Effects of Shoulder Flexion Loaded by an Elastic Tubing Band on EMG Activity of the Gluteal Muscles during Squat Exercises

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**Abstract.** [Purpose] We investigated the effects of shoulder flexion loaded by an elastic tubing band during squat exercises, by assessing electromyographic activities of the gluteus maximus and gluteus medius. [Subjects] In total, 17 healthy males were recruited. [Methods] Participants performed squat exercises with and without shoulder flexion loaded by a tubing band. Gluteal muscle activities during the downward and upward phases of the squat exercises were recorded using a surface electromyography (EMG) system. The mean electromyographic activities of the gluteal muscles during squat exercises with and without loaded shoulder flexion were compared using the paired t-test. [Results] Electromyographic activities of the gluteus maximus and gluteus medius were greater in both the upward and downward phases of the squat with loaded shoulder flexion. [Conclusions] The combination of squat and loaded shoulder flexion can be an effective exercise for increasing gluteal muscle activity.

**Key words:** Squat exercise, Gluteus maximus, Gluteus medius

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## INTRODUCTION

Gluteal muscle strengthening exercises are used frequently in prevention and rehabilitation training programs in clinical practice<sup>1)</sup>, because the gluteus maximus and gluteus medius control hip motions in the frontal, sagittal and transverse planes<sup>2)</sup>. Excessive hip adduction and internal rotation during walking or going up and down stairs, caused by gluteal muscle weakness, can change the alignment of the lower extremity<sup>3, 4)</sup>, leading to lower extremity injuries<sup>5–7)</sup>.

Among the exercises for strengthening gluteal muscles, squat exercises are commonly prescribed in clinical practice<sup>8, 9)</sup>. A previous study reported the gluteal muscles showed greater electromyographic activity during single-legged than in double-legged squat exercises<sup>10)</sup>. However, single-legged squatting can cause inadequate alignment of the lower extremity, such as knee valgus<sup>3, 4, 11)</sup>. Thus, a modified method that facilitates gluteal muscle activity during a double-legged squat exercise is needed.

It has been reported that loaded shoulder movements increase trunk muscle activity<sup>12, 13)</sup>. Researchers have suggested that shoulder movements facilitate trunk muscle activity to counteract the postural demands or reactive force caused by shoulder movement<sup>12–14)</sup>. From this point of view, squat exercises with loaded shoulder movements may lead to greater electromyographic activity in the gluteal muscles, as well as the trunk muscles, while maintaining appropriate alignment of the lower extremity. However, no previously reported study has examined whether loaded shoulder movement, in fact, facilitates gluteal muscle activity. Thus, the purpose of the present study was to determine the effects of loaded shoulder flexion, using an elastic tubing band, on gluteal muscle activity during a double-legged squat exercise.

## SUBJECTS AND METHODS

In total, 17 healthy males (mean age: 23.06±1.47 years, mean height: 172.88±5.65 cm, mean weight: 68.29±4.69 kg) were recruited for this study. Potential participants were excluded if they had a history of neurological disease or surgery of the lower extremity. This study was approved by the Inje University Institutional Research Review Committee. All participants gave their written informed consent prior to participation in this study.

A Delsys surface EMG system (Delsys Inc., Boston,

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**Table 1.** EMG activities of the gluteus maximus and gluteus medius during squat exercises with and without loaded shoulder flexion using an elastic tubing band

Phases	Muscles	Mean $\pm$ SD (%MVIC)	
		Without tubing band	With tubing band
Downward	Gluteus maximus	6.67 $\pm$ 4.25	8.56 $\pm$ 5.61*
	Gluteus medius	8.82 $\pm$ 3.91	12.09 $\pm$ 6.29*
Upward	Gluteus maximus	7.72 $\pm$ 4.12	10.66 $\pm$ 5.67*
	Gluteus medius	8.44 $\pm$ 3.59	11.58 $\pm$ 5.96*

\*p &lt; 0.05

MA, USA) was used to measure the electromyographic activities of the gluteus maximus and gluteus medius of the dominant leg during squat exercises. The sampling rate was 2,000 Hz and data were bandpass filtered between bandwidth 20–450 Hz. The EMG electrodes were attached on the landmarks of the gluteus maximus and gluteus medius, according to Criswell<sup>15</sup>. To normalize muscle activity, maximum voluntary isometric contractions (MVICs) of the gluteal muscles were measured using the methods described by Kendall et al<sup>16</sup>. The MVICs of each muscle were collected for 5 s, and two trials were performed for each muscle separated by a 1-min rest period. The mean value of the middle 3 s of the two trials was used to calculate the %MVIC of each muscle.

All participants performed squat exercises with and without loaded shoulder flexion while maintaining a knee-over-foot position. The start position for all squat exercises was an upright standing position with the feet shoulder-width apart. Participants were asked to flex their knees until the tip of the patella reached a target bar (downward phase), and to return to an upright standing position (upward phase) to perform the squat exercises. A target bar was placed in front of the participants and adjusted so that the tip of the patella reached the target bar when performing 60° of knee flexion. The downward and upward phases of the squat exercises were performed for 3 s, respectively, in time with the beat of a metronome. For squat exercises with loaded shoulder flexion, a blue elastic tubing band (Thera Band, Hygenic Corp., USA) was placed under the feet. Participants were instructed to grip the tubing band at the level of the iliac crest to minimize differences in resistance provided by the tubing band, and then performed 90° of shoulder flexion. The height of the hand was maintained for a constant length of the tubing band during squat exercises with loaded shoulder flexion. In the squat without loaded shoulder flexion, participants crossed their arms over their chests and performed the squat exercises. All participants repeated the squat exercise with and without loaded shoulder flexion three times.

The mean value of the gluteal muscle activity during the downward and upward phases of each trial was calculated, and the mean value of three test trials under each condition was expressed as %MVIC for data analysis. The EMG activities of the gluteus maximus and gluteus medius between the two conditions were compared using the paired t-test. The PASW Statistics software (ver. 18.0; SPSS, Inc., Chicago, IL, USA) was used for statistical analyses. Statistical

significance was accepted for values of p < 0.05.

## RESULTS

Gluteus maximus and gluteus medius muscle activities during the downward (p = 0.007 and p = 0.008, respectively) and upward phases (p < 0.001 and p = 0.012, respectively) significantly increased during the squat exercises with loaded shoulder flexion compared with without loaded shoulder flexion (Table 1).

## DISCUSSION

The present study showed that a combination of squat exercises and loaded shoulder flexion enhanced the electromyographic activity of the gluteus maximus and gluteus medius, compared with general squat exercises. It has been reported that shoulder movements facilitate contralateral muscle activity in response to postural demands<sup>12, 14</sup>. Thus, in the present study, shoulder flexion may have induced an anterior displacement of the center of mass, requiring greater the posterior muscle activity. Moreover, the gluteal muscles have an important role in maintaining the neutral alignment of the lower extremity<sup>3, 4, 11</sup>; thus, loading shoulder flexion with the elastic tubing band resulted in greater electromyographic activity in the gluteus maximus and gluteus medius during the downward and upward phases of the squat in this study.

We used an elastic tubing band to provide resistance during the squat exercises. Such tubing bands are less costly than other strengthening devices and easy to use. Furthermore, the intensity of exercise can be adjusted, because the resistance provided changes with the length of the tubing band<sup>17</sup>. Thus, a squat exercise using an elastic tubing band may be useful when the goal of the exercise is to strengthen the gluteal muscles. In addition, the shortest length of elastic tubing band that does not induce abnormal alignments of lower extremity may be the most appropriate for providing the best resistance force for strengthening gluteal muscles of individuals during squat exercises.

This study had several limitations. First, only male subjects participated, so generalizing the findings to other populations is problematic. Second, we did not collect kinematic data. In a future study, we will determine whether the increased electromyographic activity of the gluteal muscles due to the loaded shoulder flexion changed hip and/or knee kinematics during the squat exercise.

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