Activation of VMO and VL in Squat Exercises for Women with Different Hip Adduction Loads

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Abstract. [Purpose] The purpose of this study was to investigate the activation of the vastus medialis oblique muscle (VMO) and vastus lateralis muscle (VL) during squat exercise with various hip adduction loads using a pressure-biofeedback unit, and to suggest the most effective exercise method. [Subjects] We recruited 15 healthy adult females with no pain in the knee joint and no other orthopedic problems of the lower limbs. [Methods] The enrolled individuals performed four exercises (conventional squat exercise, maximal load hip adduction squat exercise, 80% hip adduction squat load exercise, 40% hip adduction load squat exercise). [Result] VMO was more active at 80% and 40% hip adduction loads than in the conventional squat and maximal loading hip adduction squat exercises. [Conclusion] We suggest using a 40%~80% hip adduction load in squat exercises for VMO strengthening in the clinical setting. 

Key words: Squat exercise, Hip adduction, VMO

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is an overuse injury characterized by an aching pain in the peripatellar area1–3). In general, women have wider pelvies, greater hip varus, larger hip width to femoral length ratio, and increases in lateral patellar contact forces. One of the main mechanisms of abnormal patellar tracking in PFPS is an imbalance in the activity of the vastus medialis oblique muscle (VMO) muscle relative to the vastus lateralis muscle (VL)4, 5). Many exercises emphasize the importance of the VMO6–8). Anatomic cadaver studies have shown that fibers of VMO originate from the distal part of the adductor magnus; thus VMO is provided with a stable origin from which to contract in hip adduction9). Hip adduction also stretches the VMO fibers, adjusting the length and tension properties of the muscle and increasing the contraction force. Previous research has used maximum hip adductor contraction during squat exercises. Much effort is required to maintain maximum contraction during an examination period, and subjects actually have difficulty in confirming the maximum muscle contraction. Therefore, the aim of the present study was to assess the effect of different relative hip adduction loadings on VMO and VL EMG activity, with the goal of establishing the most efficient way to perform squat exercises for promoting a higher activation of VMO.

SUBJECTS AND METHODS

Fifteen female subjects with no known surgical, musculoskeletal, or neurological history of any pathological condition in the lower extremities participated in this study. The mean age of the participants was 23.67 ± 3.48 years, their mean height was 162.33 ± 4.85 cm, and their mean weight was 52.93 ± 5.20 kg. The electrical activity of the VMO and VL was recorded using surface EMG electrodes (Biopac System Inc. Santa Barbara, CA. USA). Prior to data analysis, all results were normalized by calculating them as a percentage of their maximal voluntary contraction (%MVC). Subjects were instructed to bend their knees to 45° and hip adduct their knees together. Subjects performed conventional squats and squat with various hip adduction loads (maximum, 80% load, and 40% load). Squat exercises were executed in the following sequence. The conventional squat exercise was performed by descending to 45° knee flexion, holding for 6 s, and ascending to the initial position. Squat exercises with various hip adduction loads were performed by compressing a biofeedback air cushion placed between the medial joint lines of the knees. Subjects inserted the air cushion between their knees and squeezed it at maximum effort for 6 seconds, and this sustainable status was defined as the maximal hip adduction. Maximal, 80%, and 40% hip adduction load squat exercises were performed by descending to 45° knee flexion and holding for 6 seconds. The data were analyzed using SPSS version 18.0 (Chicago, IL, USA) to examine the significance of differences in activation of the VMO and VL muscles among the squat exercises. A one-way repeated measures ANOVA was initially performed to determine significant differences in the activity of each muscle during the exercises. Bonferroni’s
The EMG activity of VMO was more active at the 80% and 40% hip adduction loads than in the conventional squat and maximal load hip adduction squat exercises (p<0.05). The EMG activity of VMO was higher at 80% than at 40% hip adduction load. The normalized EMG values of VMO during 80%, 40%, maximal, and conventional squats were 44.73±14.58%, 42.38±17.62%, 42.03±13.79%, and 35.45±14.70%, respectively. No statistically significant differences were noted among the activities of the VL muscle (p>0.05). The normalized EMG values of the VL muscle during the 80%, maximal, 40%, and conventional squats were 39.36±18.24%, 38.86±18.67%, 36.42±18.28%, and 33.13±16.15%, respectively.

**RESULTS**

Rehabilitation of patients with PFPS requires strengthening of the knee muscles. Accordingly, many researchers have recommended VMO and VL muscle activation in squat exercises. This study investigated the activation of the VMO and VL muscles, to enable more precise treatment. We analyzed and compared the magnitude of the VMO and VL muscle activities in squat exercises with four different hip adduction loads. We found that the VMO muscle activity increased in squat exercises with hip adduction compared to the conventional squat exercise. This result agrees with the findings of previous studies, in which the VMO muscle showed significantly greater electrical activity during a double leg semisquat exercise associated with hip adduction. Some researchers also reported that squat exercises with maximal adduction of the hip showed an increase in the myoelectrical activity of VMO. These previous studies used squat exercises with hip adduction to establish higher EMG activity levels in VMO and VL. However, in all of these studies, maximal voluntary hip adduction was used. The present study used squat exercise with different hip adduction loads, and found significantly higher activities at 80% and 40% hip adduction loads than in the conventional squat exercise. Much effort is required to maintain maximum loading, and it is actually difficult to maintain it using biofeedback. Consequently, compensatory movement or irregular activation of muscles might occur. Therefore, we suggest using 40%–80% hip adduction load during squat exercises for VMO strengthening in the clinical setting. Further EMG investigation is necessary to determine the most appropriate hip adduction load, as well as to clarify the differences between PFPS and healthy persons, in order to compare the effects of muscle training programs utilizing various hip adduction loads in squat exercises.

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**REFERENCES**