J. Phys. Ther. Sci.
27: 2861–2862, 2015

Original Article

Effects of the slow speed-targeting squat exercise on the vastus medialis oblique/vastus lateralis muscle ratio

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Abstract. [Purpose] This study investigated the effects of the slow speed-targeting squat exercise on the vastus medialis oblique/vastus lateralis ratio. [Subjects] Ten asymptomatic men were recruited. [Methods] The EMG activities of the vastus medialis oblique and vastus lateralis muscles were recorded using surface electrodes. The subject performed the squat exercise under 3 different conditions. [Results] The vastus medialis oblique/vastus lateralis ratio in condition 2 (1.5 ± 0.7) was significantly higher than that in conditions 1 and 3 (1.0 ± 0.5, 1.1 ± 0.8, respectively) [Conclusion] Therefore, an effectively slow movement speed is recommended for selective strengthening of vastus medialis oblique using a slow speed-targeting device that provides biofeedback.
Key words: Slow movement speed, Squat exercise, VMO

(This article was submitted May 11, 2015, and was accepted Jun. 9, 2015)

INTRODUCTION

Patellofemoral pain syndrome (PFPS), characterized by severe pain around the knee, is caused by displacement of the patella from its position between the femoral condyles[1)]. Repetitive occurrence of this displacement may lead to the development of degenerative arthritis due to the resulting abrasion of the articular surface[2)]. Many studies have demonstrated that in patients with PFPS, the patellae are dragged excessively outward[3)]. It has been reported that this excessive outward dragging is caused by an imbalance between the vastus medialis oblique (VMO) and vastus lateralis (VL) muscles and is the main cause of PFPS[2, 3)]. However, the etiology of PFPS has not yet been clearly defined. One of the main mechanisms for abnormal patellar tracking in PFPS is an imbalance in the muscle activity of the VMO relative to the VL[4, 5)]. Therefore, several exercise interventions emphasize the importance of the VMO[5, 6)]. The squat exercise is a common weight bearing exercise used by athletes and other individuals with healthy knees to train the hip and thigh musculature[7)]. Several studies have reported that a remarkably weaker VMO or delayed activation of the VMO compared with the VL is due to an imbalance between the two muscles[2)]. The squat exercise does not cause an anterior shear force because of the cooperative contraction of the quadriceps and the hamstrings in the patellofemoral joint, and functional muscle recruitment patterns can be provided as many joints move[4–6)]. A previous study demonstrated that an intervention program, which involved the use of one's own body weight as resistance during performance of exercises at a slow movement speed, improves physical function[7)]. Therefore, in this study, a slow speed-targeting squat exercise device was developed, and the effects of the slow speed-targeting squat exercise on the VMO/VL ratio were investigated.

SUBJECTS AND METHODS

This study involved 10 asymptomatic men aged 35.4 ± 2.0 years (mean ± SD), with a mean height and weight of 176 ± 5.1 cm and 65.0 ± 3.2 kg, respectively. All subjects were healthy and free of back pain for a minimum of 1 year before the study; they had no lower limb or spine pathologies and no rheumatological or neurological conditions. The purpose and procedures of the study were explained to the subjects prior to their participation, and they provided informed consent according to the ethical principles of the Declaration of Helsinki.

The EMG signals were sent to the data acquisition unit of the MP150 system (BIOPAC Systems, Santa Barbara, CA, USA). The EMG data were analyzed using a program created with the AcqKnowledge software (version 3.9.1) and expressed as the maximum voluntary contraction. Surface electrodes were attached over the VL and VMO. EMG surface electrodes were placed on the muscle belly of the VMO, 4 cm superior and 4 cm medial to the supromedial border of the patella, at approximately 55 degrees to the long axis of the femur. The VL electrode was placed 10 cm superior and 6–8 cm lateral to the superior lateral border of the patella and orientated 15 degrees to the vertical. The subjects stood with

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their heels and back against the wall, allowing their back to slide down the wall during the squat. They performed the squat exercise to 60 degrees of knee flexion. The knee flexion angle was controlled by the guide bar. In this study, the slow speed-targeting device was applied on the front of the subject's knees. The tester provided instructions for squat exercises at three exercise speeds. Condition 1 was the usual-speed squat exercise. Condition 2 was 70–50% below slow speed squat exercise for habitual speed using the slow speed targeting device. Data on the speed used were provided by the slow speed-targeting device. This device has two display components, which show: (1) the current velocity and (2) the broken record data for slow velocity. Condition 3 was the super-slow speed squat exercise without use of the targeting device. To test for differences in the VMO/VL ratio among the different squat exercise conditions, repeated-measures analysis of variance was used to determine if the exercise speed had a significant effect on the VMO/VL ratio. For the significant main effect, Bonferroni's correction was performed to identify the specific mean differences. Differences were defined as significant at $p < 0.05$.

RESULTS

The VMO/VL ratio in condition 2 (1.5 ± 0.7) was significantly higher than that in conditions 1 and 3 (1.0 ± 0.5, 1.1 ± 0.8, respectively) ($p < 0.05$).

DISCUSSION

In this study, a slow speed-targeting device was developed, and the effects of the slow speed-targeting squat exercise on the VMO/VL ratio were investigated. According to the study results, the VMO/VL ratio in condition 2 (slow speed-targeting squat exercise) was significantly higher than that in conditions 1 (habitual speed) and 3 (super-slow speed without use of the targeting device). A previous study reported that super-slow training is an effective method for increasing strength in middle-aged and older adults. Although studies on at-risk populations are yet to be performed, repetition speed should be considered when prescribing resistance training[8]. Additionally, slow-speed resistance training has been shown to effectively cause an increase in muscular strength[8]. Maintaining a slow movement speed in both lifting and lowering actions may be necessary to achieve constant tension. Another study demonstrated that an intervention program using one's own body weight as resistance during slow movement and plyometric exercise can improve physical function in the elderly, even with single sets for each exercise[7]. However, there was no enhanced muscle hypertrophy effect. Exercise utilizing a biofeedback program is very effective. Yoo suggests that proper selection of the push-up exercise speed may be necessary for selective strengthening of the serratus anterior and that isokinetic biofeedback information obtained using an accelerator can help in selective strengthening of the middle SA[9]. Squat exercises are often used in the rehabilitation of individuals with knee pathologies in the field of physical therapy. According to these results, the super-slow speed squat exercise without targeting was not an effective exercise for selective strengthening of the VMO. A slow speed-targeting device was developed in this study for selective strengthening of the VMO in subjects with PFPS. This device provides the biofeedback information for a slightly slow-speed (50–70%) exercise. Therefore, an effectively slow movement speed is recommended for selective strengthening of the VMO, with the use of a slow speed-targeting device that provides biofeedback.

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