Effects of Various Foot Wedge Boards on Vastus Medialis Oblique and Vastus Lateralis Muscles during Lunge Exercise

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Abstract. [Purpose] This study applied the lunge exercise using a variety of foot wedge boards to analyze differences in the muscle activities of the vastus lateralis (VL) and vastus medialis oblique (VMO) and the VMO/VL ratios. [Subjects] This study was performed on 20 asymptomatic males. [Methods] Surface electromyography measurements were obtained under 5 lunge exercise conditions. [Result] The EMG activity for the VL muscle significantly increased in the order of conditions as follows: anterior wedge < no wedge and medial wedge < lateral wedge and posterior wedge. The EMG activity for the VMO muscle significantly increased in the order of conditions as follows: anterior wedge < no wedge and lateral wedge < medial wedge and posterior wedge. The VMO/VL ratios under the medial wedge and posterior wedge conditions were significantly increased. [Conclusion] Use of medial and posterior wedge boards during the lunge exercise can selectively strengthen the VMO.

Key words: Foot wedge board, Patellofemoral pain syndrome, VMO/VL ratio

INTRODUCTION

Recent studies emphasize the necessity of balance between the vastus lateralis (VL) and vastus medialis oblique (VMO) for treatment of patellofemoral pain syndrome (PFPS)1). Several studies have reported that a remarkably weaker VMO or delayed activation of the VMO compared with the VL is due to imbalance between the VMO and VL2). Open chain exercise increases anterior shear force and induces excessive tension of the anterior cruciate ligament3). On the other hand, closed chain exercise (CCE) does not cause anterior shear force because of the cooperative contraction of the quadriceps and the hamstring in the patellofemoral joint, and functional muscle recruitment patterns can be provided as many joints move4, 5). CCEs to strengthen the quadriceps femoris muscle have been performed in various forms of exercises. In the present study, we applied the lunge exercise most frequently used among CCEs using a variety of foot wedge boards to analyze differences in the muscle activities of the VL and VMO and the VMO/VL ratios.

SUBJECTS AND METHODS

This study was performed on 20 asymptomatic males aged 25.4±3.2 years (mean± SD); their heights and weights were 176±2.5 cm and 69.5±4.7 kg, respectively. All subjects were healthy and had been free of any 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 EMG signals were sent to the data acquisition unit of an 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 (MVC). Surface electrodes were attached over the VL (vastus lateralis) and VMO (vastus medialis oblique). The subjects maintained a neutral trunk alignment with right knee flexion of 90 degrees and left hip and knee extension. The trunk posture was defined as anterior rotation of the pelvis for a neutral lumbar lordosis and relaxation of the thorax with an upright head posture. The experimental protocol specified 5 lunge exercise conditions: condition 1 applied no foot wedge board; condition 2 applied an anterior wedge board to the foot; condition 3 applied a medial wedge board to the foot; condition 4 applied a lateral wedge board to the foot; and condition 5 applied a posterior wedge board to the foot. The angle of the wedge was 20 degrees (L×W×H: 30 × 30 × 15 cm). The order in which subjects performed the trials with the different foot wedges was randomized to prevent any learned effects. The EMG signal was collected for 30 seconds, excluding the first and last 10 seconds. To test for differences in VMO and VL muscle activities and the VMO/VL ratio among the various foot wedge board conditions, repeated-measures analysis of variance was used to determine if there was a significant effect of the muscles and 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.

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RESULTS

The EMG activity for the VL muscle increased significantly in the order of conditions as follow: anterior wedge (50.9±11.7%) < no wedge (58.5±9.7%) and medial wedge (56.6±10.1%) < lateral wedge (63.5±8.5%) and posterior wedge (67.4±10.7%) (p<0.05). The EMG activity for the VMO muscle increased significantly in the order of conditions as follow: anterior wedge (49.7±10.1%) < no wedge (58.0±11.0%) and lateral wedge (56.1±11.4%) < medial wedge conditions (69.9±13.5%) and posterior wedge (74.5±11.7%) (p<0.05). The VMO/VL ratio was more significantly increased under the medial wedge (1.25±0.25) and posterior wedge conditions (1.21±0.18) than under the no wedge (0.99±0.13), anterior wedge (0.99±0.14) and lateral wedge conditions (0.91±0.10) (p<0.05) (Fig. 1).

DISCUSSION

Cook et al. suggested that the squat exercise on a 30-degree posterior slope was more effective in activating the VMO than the same exercise on the ground because it minimized the effect of the gastrocnemius muscle. In this result, use of a posterior wedge board during the lunge exercise relaxed the gastrocnemius muscle, so the VL and the VMO showed higher muscle activities than when exercises were performed with a variety of postural changes on the ground and showed the highest VMO/VL ratios. On the other hand, the lunge exercise on an anterior wedge board showed the lowest activity of the VMO and VL. It is considered that gastrocnemius muscle tension increased due to the anterior wedge board. Thus, the gastrocnemius muscle acted more on knee extension, thereby relatively reducing the activity of the quadriceps muscles. In this study, when the lunge exercise was applied with a medial wedge board, significant increases in VMO/VL ratios were shown along with high activity of the VMO. The exercise on a medial wedge board causes resistance to hip adduction. This exercise showed results consistent with the hypothesis that if hip adduction is also induced, the muscle activity of the VMO will increase based on the fact that the VMO originates in the distal part of the adductor magnus muscle. In the present study, when a lateral wedge board was applied, only the activity of the VL increased greatly. In this case, the VL would be overused because the muscle should pull against contracted states. Appropriate wedges applied to the feet may prevent the tibia from rotating and correct the misalignment of the Q-angle to prevent basic factors of PFPS. The medial wedge board used in the present study can also be used as a treatment method for misalignment with an excessive Q-angle. Saxena and Haddad reported that when they applied foot wedges to patients with PFPS and conducted biomechanical tests, the range of motion significantly increased along with the alleviation of knee pain; hence, they suggested that wedges could be therapeutically applied. Use of medial and posterior wedge boards during the lunge exercise can selectively strengthen the VMO.

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