

LOWER EXTREMITY COORDINATED MOBILIZATION AND STABILIZATION DURING STATIC STANCE: THE UNIQUE ROLE OF THE VASTI MUSCLES

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INTRODUCTION

Neuromuscular control strategies have been investigated during a variety of tasks [1,2], and many theories on motor coordination and synergies have been suggested. Different control strategies have been proposed for the limb that mobilizes (e.g., kicks a ball) when compared to the limb that stabilizes (e.g., in stance while the other leg is kicking) [3].

Knee injuries are common during cutting sports, and most often the knee that is injured is the one in stance providing stabilization. We hypothesized that the mobilizing limb would be more specific than the stabilizing limb. The purpose of this study was to investigate if differences in neuromuscular control exist about the knee between the stabilizing and mobilizing limbs during a standing posture.

METHODS

Eleven uninjured athletes (mean age 24.9 ± 2.7 years) volunteered to participate in this study to date. All subjects were regular participants in high level sports. Subjects were positioned standing with their bare feet on a force platform (a separate force platform was used for each foot). Subjects were given visual feedback of their forces on the 6 degree of freedom force platform and were asked to use this information to produce specific static postures. One foot was randomly selected to mobilize the cursor, while the other stabilizing foot's forces did not affect the cursor. The subjects' goal in the experimental protocol was to use their mobilizing foot to position a circular cursor over a narrow target that consisted of two concentric circles. Subjects were instructed to equally divide their body weight between the force plates and simultaneously produce forces tangential to the plane of the force plate. Targets appeared in a random order at one of 18 positions (located at 20° increments of a circle in the forward-backward-

medial-lateral plane). Seventy-two trials were performed bilaterally (both feet performed the mobilizing task). A load of 30% of maximum forward-backward force (collected prior to trials) was required to move the cursor in to the target. Subjects were required to hold the cursor within the narrow target for 0.5 seconds before the trial was considered successful.

Electromyography (EMG) activity of 11 muscles, of both legs, was collected from the medial hamstrings (MH), lateral hamstrings (LH), rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), medial gastrocnemius (MG), lateral gastrocnemius (LG), tibialis anterior (TA), gluteus medius (GM), soleus (SOL), and adductors (ADD) during the final 0.5 second in each target using surface electrodes. The data were full wave rectified, averaged, and normalized using maximum EMG data collected earlier in the session.

Muscle activity at each of the targets was plotted in polar coordinates. The directional EMG data for the stabilizer foot were transposed, so that polar plots represent the muscle activity of both the stabilizer and mobilizer under the same external forces.

The specificity of muscle utilization was analyzed by calculating a specificity index [4] for each muscle. Vector addition was used to calculate the overall magnitude and direction of muscle activity (EMG) based on the polar plots. The specificity index was calculated by dividing the vector sum by the scalar sum, for a value that ranged between zero and one.

RESULTS AND DISCUSSION

The adductors were most active in the medial direction, and gluteus medius was most active in the lateral direction, for both the mobilizing and

Vastus Lateralis

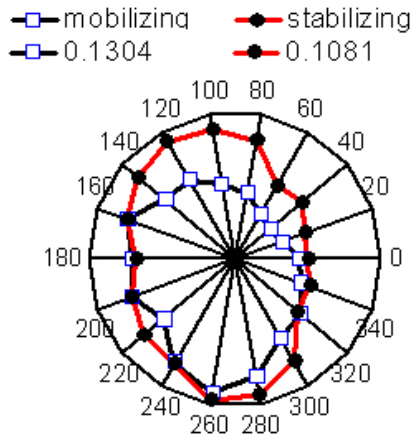


Figure 1: Polar plot of EMG demonstrates the stabilizing VL is more active than the mobilizing VL while pushing forward against the force platform (legend above indicates mobilizing and stabilizing limb and the EMG proportion of MVC).

stabilizing limb. Hamstrings were utilized primarily in the backward direction, for both the mobilizing and stabilizing limb. Rectus femoris was primarily active in the forward direction. These results were not surprising as they correspond to the mechanical moment arms of the muscles.

Interestingly, the vasti of the stabilizing limb contracted differently from the mobilizing limb, and did not always contract in the direction that may be anticipated. For the mobilizing limb, the vasti were active primarily in the backward direction, and were relatively inactive in the forward direction. However, for the stabilizing limb, the vasti were active during both forward and backward directions (Fig. 1). Further, the specificity index for the vasti of the stabilizing limb was smaller than of the mobilizing limb (Fig. 2).

We found a synergistic relationship between the vasti and hamstring muscles of the mobilizing limb. The vasti do not usually act synergistically with the hamstrings except while co-contracting, and the lack of hamstring and vasti muscle activity while pushing forward indicates this was not a typical co-contraction. These results are surprising, and may represent a strategy to stabilize the knee joint with the vasti while the hamstrings mobilize the entire lower extremity.

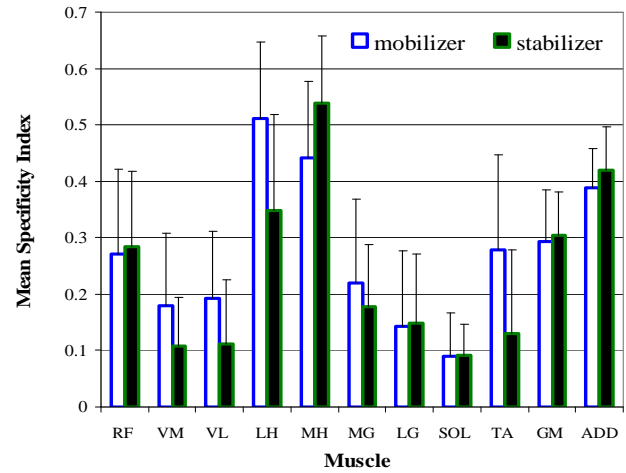


Figure 2: Comparison of mean specificity indices between mobilizing and stabilizing limb indicates differences exist for the vasti muscles.

Knee injury has been found to reduce vasti muscle specificity [4]. Perhaps both the stabilizing and mobilizing limb of ACL deficient subjects would have decreased vasti specificity when compared to healthy individuals. A more global co-contraction of the muscles about the knee could increase joint loading, and explain a portion of the increased incidence of post-traumatic osteoarthritis.

While these data are preliminary, our findings suggest that the vasti of the mobilizing limb have more specific neuromuscular control strategies than the stabilizing limb. Advancing our understanding of the neuromuscular control of the vasti muscles is an important contribution to knee injury prevention and rehabilitation programs.

CONCLUSIONS

We believe the neuromuscular control strategies appear to be less specific for the stabilizing than the mobilizing limb. The vasti muscles play an important role in stabilizing the knee while multi-joint muscles mobilize the limb.

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