THE ROLE OF THE VASTUS MEDIALIS AND VASTUS LATERALIS IN MEDIAL-LATERAL KNEE JOINT STABILITY

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INTRODUCTION

It has been shown that activation of some or all of the quadriceps with the proper distribution would alter the patellar kinematics [1]. Change of patellar kinematics may influence the individual quadriceps moment output at the knee joint [2]. The goal of our study is to examine the effect of patellar kinematics on the role of individual quadriceps muscles in medial-lateral control of the knee. To achieve this, patellar kinematics are changed by providing different background activation of all quadriceps prior to the selective electrical stimulation of an individual knee muscle. The quadriceps muscles examined were the vastus lateralis (VL) and the vastus medialis (VM). The resulting abduction/adduction to extension moment ratio, obtained under the superimposed selective stimulation, is then compared across the different background activation levels.

METHODS

Six healthy young males with no history of knee degeneration or neurological diseases participated in the study (25.5 +/- 3.9 yrs; 70.9 +/- 4.5 in; 174.7 +/- 34.2 lbs). The subject was seated upright with the knee flexed at an angle of 20° from a fully extended position. Twenty degrees was selected because the vasti muscles are most active between 10 and 20° of flexion. Prior to each experiment, the subject's Maximum Voluntary Contraction (MVC) extension moment (M_{ext}^{MVC}) was recorded using a six degree-of-freedom (6-DOF) load cell. Prior to the electrical stimulation experiments, subjects were asked to generate an extension moment (M_{ext}) as a percentage of their MVC extension moment using a visual display of the desired level $(M_{ext}^{back} = 100 \cdot M_{ext} / M_{ext}^{MVC})$. Eight pre-activation levels (0 to 30-35% of M_{ext}^{MVC}) were used. Selective electrical stimulation was applied to the VM and VL in alternating trials, with the resulting forces and moments measured using the 6-DOF load cell. The load cell was centered at the lateral femoral condyle of the knee with its long axis aligned with the transcondylar line of the femur. Two sterilized bipolar intramuscular electrodes (50µm) were inserted using 27 gauge hypodermic needles. The interelectrode distances and the electrode locations were confirmed by stimulating the muscle and verifying that the appropriate muscle contraction had occurred. The stimulus intensity was chosen to maintain sufficient muscle force with minimal discomfort. To insure selectivity of the electrical stimulus, EMG activity of the neighboring muscles was recorded with intramuscular electrodes to detect the maximum level of current that could be used with minimal electrical spread. The stimulus profile was a rectangular mono-phasic constant current with 0.3 ms pulse duration. Train duration was 500 ms with a 20 ms interval, repeated every 2 s. For each subject, at least fifteen contraction cycles were obtained. The three-dimensional moments measured at the load cell center were transformed to the center of the knee joint, defined as the midpoint of the transcondylar line of the femur, and the adduction/abduction moment to the extension moment ratio was then computed.

RESULTS AND DISCUSSION

To assess the effect of changing patellar kinematics on the medial-lateral stabilizing role of the quadriceps, moment ratio was computed from knee moments measured as a result of the selective electrical stimulation of lateral (VL) and medial (VM) muscles. In figures 1 and 2, a positive ratio indicates an abduction torque production. The data shown in Figures 1 and 2 indicate that both VM and VL are capable of generating sufficient off-axis moments. The VL moment ratio was consistent in its trend and sign across all six subjects (data not shown). The magnitude of the moment ratio increased systematically with increasing of M_{ext}^{back} (see Figure 1). Across all subjects, change of the patellar kinematics induced by the different M_{ext}^{back} had no impact on the fundamental role of VL. On the other hand, the medial-lateral role of the VM muscle varied significantly across subjects. For example, while the moment ratios obtained on S1 and S2 were similar in sign and magnitude at low M_{ext}^{back}, they were significantly different at higher levels of M_{ext}^{back} (see Figure 2). At higher background activations, only modest variation of the S2 moment ratio occurred while a significant decrease of the same ratio was evident for S1. In fact, moment ratio data of S1 reversed sign, indicating that at higher pre-activation levels, the VM muscle reversed role from an abductor to an adductor of the knee joint. Contrary to the S1 and S2 data shown in Figure 2, in other subjects, activation of VM at rest generated adduction moment and moved towards abduction as the M_{ext}^{back} levels were increased (data not shown).

SUMMARY

Across all subjects, the VL was found to be predominantly an abductor of the knee joint. These results were not as clear for the traditionally known adductor of the knee, the VM muscle. Our preliminary data indicates a potential role reversal of the VM as a function of the patellar kinematics or background extension moment. The cause of across subject variability in the role of the VM is not yet clear from the current data. This matter could potentially be addressed with a larger number of subjects.

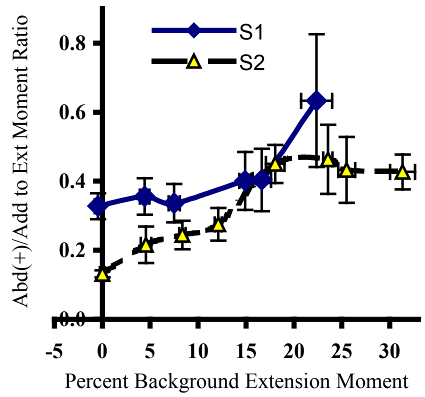

Figure 1: VL moment ratio obtained on two representative subjects, S1 & S2.

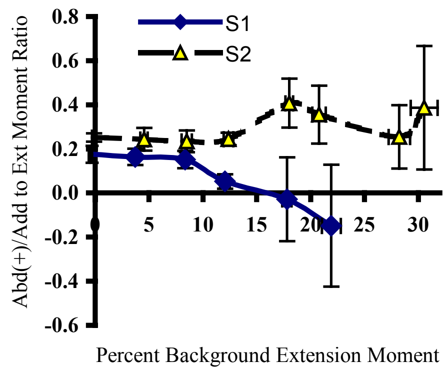

Figure 2: VM moment ratio obtained on two representative subjects, S1 & S2.

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REFERENCES

1.Goh, J.C., et al. Journal of Bone & Joint Surgery - British Volume, 1995. **77**(2): p. 225-31.
2.Lafortune, M. and P. Cavanagh, eds. International Series on Biomechanics, ed. B. Jonsson. Vol. Biomechanics X-A. 1987, Human Kinetics Publishers, Champaign, Illinois. 337-341.