QUADRICEPS FEMORIS MUSCLE MORPHOLOGY AND KINEMATICS DURING DYNAMIC CONTRACTIONS USING MRI
Finni Taija¹, Havu Marko¹, Usenius Jussi-Pekka², Sinha Shantanu³, Cheng Sulin⁴
(Department of Biology of Physical Activity, University of Jyväskylä¹, Finland, Nomir Oy², Finland, Department of Radiology, UCSD³, USA, Department of Health Sciences, University of Jyväskylä⁴, Finland)

This study investigates the nature of the interaction between the two-joint rectus femoris (RF) and one-joint vastus muscle (VI) during a submaximal dynamic knee extension movement. Our working hypothesis is that the compartmentalized structure of the vastus muscle and a radially bipennate RF muscle form a functional unit where the existing major connective tissue structures are likely to have an important role in force transmission through the RF-VI aponeurosis function.

Using a cine phase-contrast magnetic resonance imaging (Sinha et al. 2004) we examined two-dimensional tissue deformations (anatomy, displacement, strain) in axial and sagittal planes within the quadriceps femoris muscle in 11 males. Lying in prone position inside the magnet bore, the subjects were asked to perform repeated knee extensions against a calibrated load. Outside MRI, muscle electromyographic activity was recorded from three thigh muscles during the same task. Also maximum voluntary contraction (MVC) was recorded at 150 degree knee joint angle in seated position.

During a concentric knee extension RF moved laterally and the muscle mass in all compartments shifted proximally. The mean maximum displacement of the RF and VI was similar on both sides of the aponeurosis (20.4 mm in RF and 21.2 mm in VI). When the aponeurosis was divided into distal and proximal 50% portions, the maximum displacement was greater in the proximal part of both RF and VI (p<0.05). The strain in distal and proximal aponeurosis at the time of maximum displacement was similar and varied from 0-2%. Individually, we identified three patterns of interaction between the RF and VI: 1) VI moved more than RF (n=5), 2) RF moved more than VI (n=3) and 3) on average RF and VI moved the same distance (n=3). There were differences in EMG activity between these three groups in VI (p<0.05) but not in RF measured as % MVC at 150 degree knee joint angle during the movement. In the group where VI moved more than RF the VI EMG activity was 7% MVC as compared to the other two groups with about 2% MVC. There was also a tendency for muscle cross-sectional area to correlate with the three different patterns of muscle interaction (r=0.59, p=0.054).

To summarize, the RF-VI aponeurosis stretches slightly but uniformly during submaximal knee extension. However, individual differences in muscle-tendon interaction were found, and they may be related to the level of muscle activity and muscle size. Thus it may be suggested that muscle coordination and anatomy play a role in the mechanics of force transmission within the muscle-tendon unit and between different muscles.