THE PASSIVE CONTRIBUTIONS OF THE VASTUS MEDIALIS AND VASTUS LATERALIS TO KNEE EXTENSION AND HIP FLEXION

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INTRODUCTION

Muscles primarily transmit forces through tendon, but also transmit forces to neighboring muscles through myofascial connections. These adhesions strengthen following surgery as scar tissue, which produces greater myofascial force transmission and less tendon force transmission [1]. Musculoskeletal injuries may lead to greater intermuscular fibrosis [2], strengthening these myofascial connections. Since vastus medialis tendon elongation is reduced in patellofemoral pain [3], we seek to explore if patellofemoral forces are altered by the myofascia. First, we need to understand how healthy myofascial connections affect the vastus lateralis (VL) and vastus medialis (VM). The VL and VM articulate the knee, but are adjacent to hip flexor muscles (rectus femoris, tensor fasciae latae). The VL and VM will be isometric during passive hip flexion if the myofascial connections are irrelevant. Therefore, we investigated whether the healthy VL and VM will shorten during passive knee extension and remain isometric during passive hip flexion.

METHODS

Three healthy adults (2 F, 1 M; 2 R, 1 L leg; mean age: 29 yrs, height: 175 cm, weight: 68 kg) had one leg moved within a Lokomat driven gait orthosis (Homoca, Inc.). The Lokomat was attached with three leg cuffs and a pad over the greater trochanter to prevent pelvic motion (Fig. 1). The Lokomat repeatedly moved the limb with a gait profile of 1 km/h. This profile was customized so the knee joint (10°–73° flexion) was passively moved with the hip fixed (0° flexion), or the hip joint (-16°–37° flexion) was passively moved with the knee fixed (8° flexion). The subjects were provided 50% body-weight support while standing on the contralateral limb. Muscle activity recorded with surface electromyography (EMG) of the VL, VM, rectus femoris (RF), biceps femoris (BF) and semitendinosus (ST) (Motion Lab Systems) was normalized to a maximum voluntary contraction and rectified. Data were sampled at 2 kHz.

A Siemens ACUSON Antares ultrasound system (B-mode, 13 MHz transducer, 38 mm width, 75 µm pixel resolution) was synchronized to the Lokomat and recorded motion of the VL and VM (40 Hz). The transducer was aligned to each muscle fiber orientation with a custom holder secured around the thigh to minimize movement. The transducer was distally located at ~20% femur length between the epicondyle and greater trochanter (Fig. 1). An automated Lucas-Kanade-Tomasi algorithm [4] tracked the spatial and temporal gradients between ultrasound images over one cycle of knee extension-flexion or hip flexion-extension. The displacement of two sets of four measurement probes (initially 30 mm apart) was tracked and averaged along the superficial and deep surface of the fascicle region (Fig. 1). Paired t-tests compared peak proximal displacement during hip flexion of the superficial

Figure 1: (left) Lokomat schematic. (right) Sample VL and VM ultrasound images with measurement probes tracked from peak knee flexion to peak knee extension.
and deep surfaces of the VL and VM to zero (i.e. isometric). Peak displacement of the VL and VM was analyzed with a 2x2 ANOVA (fixed: measurement surface (superficial/deep), joint moved (hip/knee); random: subject) with Tukey post-hoc tests (alpha: p = 0.01).

RESULTS AND DISCUSSION

Exemplar trials of VL during one cycle of passive knee and hip motion show tissue displacement was greater during knee extension than hip flexion, and greater deep than superficial (Fig. 2). The VL shortening during hip flexion is a novel finding since this muscle does not articulate the hip. Similar results were found for the VM (Fig. 3). EMG recordings confirm the muscles remained passive since all muscle activity was less than 1% MVC. The joint angles indicate only a single joint was moved during the experiment. During passive hip flexion, the proximal displacement of VL and VM indicates the muscles were not isometric, regardless if the measurement were superficial or deep (all 4 p-values < 0.001). There was a significant interaction between the measurement surface and the joint moved (VL & VM: p < 0.001). Post-hoc comparisons are provided in Fig. 3.

The present study shows that even in healthy subjects, the vasti muscles shorten during passive hip flexion, even though they do not articulate the hip. Similar results have been shown between the soleus and gastrocnemius [5]. It is known that myofascial connections can alter the relative motion of the quadriceps muscle following rectus femoris tendon transfer [6]. We posit that myofascial connections between the vasti and neighboring hip flexors contribute to these results. However, future work is needed to confirm this hypothesis and to determine if the length changes shown here result in significant intermuscular force transmission in both healthy and pathologic populations.

The study was limited by a small sample size and the lack of measurements of fascicle length, the distal rectus femoris (due to the thigh cuff), femoral internal rotation, and myofascial force transmission. The Lokomat also had a shorter knee cycle than hip cycle. Future work will address these concerns.

CONCLUSIONS

Displacement of the deep and superficial borders of the VL and VM indicates local shortening during passive hip flexion, even though these muscles do not articulate the hip. Future work will address if myofascial connections are responsible.

REFERENCES


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