Hip Rotation Function of the Pectineus Muscle

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INTRODUCTION:

The pectineus is a quadrangular muscle that originates from the pubis and the fibers pass down, back, and lateral, to be inserted into the femur, distal to the lesser trochanter. This muscle has a short tendon relative to overall muscle length thereby mechanically advantageous to actively produce tension throughout its range of muscle lengths during hip rotation. Although there is no study that has reported the frequency or functional consequences of pectineus muscle injuries, there is controversy regarding its mechanical role at the hip. For instance, Arnold et al. [1] reported this muscle to change from having an internal rotation moment arm to an external rotation moment arm when the femur is externally rotated; yet classic literature suggests that the pectineus muscle does not have an active role during hip external rotation [2]. Given its morphology and anterior position relative to the femur, the pectineus muscle may be an important stabilizer that controls transverse plane hip rotations. This functional role, however, is unclear. The purpose of this study was to investigate pectineus muscle activation during simple and dynamic tasks to describe its rotary function at the hip.

METHODS:

Ten healthy individuals (1.72 ± 0.04 m; 674.17 ± 43.3 N; 28.70 ± 2.00 y) participated in this study. All participants provided written consent prior to participation, in accordance with the Vail Valley Medical Center's Institutional Review Board.

The participants performed a partial squat; hip rotation with the hip in neutral and the knee at 90 deg while approximately 20% body weight was placed on a knee located on a wheeled stool; and over-ground walking. The exercises were performed at a pace of 90 bpm. Indwelling electrodes were used to record (1200 Hz) muscle activation from the pectineus muscle. The electrodes were inserted under ultrasound guidance to assure correct placement into the muscle and for patient safety. A radiologist that was blinded to the study confirmed electrode placement via inspection of the digital ultrasound pictures.

The EMG data (Bagnoli-8, DelSys, Boston, MA, USA) were processed with a 50 ms, root-mean-squared (RMS) moving window (1 ms increments) with custom software (MATLAB, Natick, MA, USA). The EMG data were scaled to a maximum EMG reference value measured during the MVC trials and represented 100% MVC.

Fifty-three retro-reflective, spherical markers (diameter =1.0 cm) were attached to select anatomical landmarks. A ten-camera motion analysis system (Motion Analysis, Cortex 1.1.4, Santa Rosa, CA, USA) was used to capture three-dimensional hip motions at a frequency of 120 Hz. The marker trajectories were low pass filtered at 10 Hz with a fourth order Butterworth filter. Three-dimensional hip kinematics were calculated (Motion Monitor, Version 7.0, Innovative Sports Training, Chicago, IL, USA) using a YXZ sequence as proposed by Grood and Suntay [3].

RESULTS:

During the hip rotation exercise, the hip externally rotated from 10.3 ± 1.5º of internal rotation to 22.9 ± 2.8º of hip external rotation. The internal rotation phases consisted of equal and opposite motions. When rising from a squatted position, the hip joint externally rotated from 0.8 ± 1.7º of hip internal rotation to 4.1 ± 1.4º of hip external rotation. The lowering phase demonstrated equal and opposite hip motions. From toe-off to the first 10% of stance phase, the hip joint externally rotated from 10.1 ± 1.5º of hip internal rotation to 3.9 ± 1.2º of hip external rotation. The remainder of the stance phase demonstrated nearly identical and opposite hip motions.

Pectineus muscle activation versus relative time for the hip rotation, partial squat and gait exercises are located in Figure 1. The first 50% of each exercise consisted of hip external rotation (lightened portion) and the last 50% consisted of hip internal rotation (darkened portion). Each exercise demonstrated similar pectineus muscle activation patterns and magnitudes during hip internal and external rotation phases regardless of whether the hip was producing a net hip internal or external rotation torque.

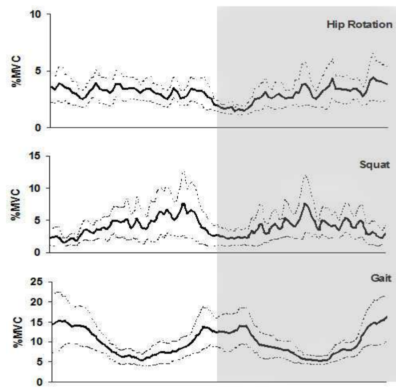

Figure 1. Pectineus muscle activation versus relative time for the hip rotation, partial squat and gait exercises. The first 50% of each exercise consisted of hip external rotation (lightened portion) and the last 50% consisted of hip internal rotation (darkened portion).

DISCUSSION:

Hip Rotation. The hip external rotation phase began when the pectineus muscle had a hip internal rotation moment arm. As hip external rotation progressed the moment arm became progressively smaller and then changed to a hip external rotation moment arm near 40% of the task [1]. This pattern was reversed during the hip internal phase. Regardless of the type of moment arm, pectineus muscle activation remained relatively constant and may indicate that this muscle does not provide an active contribution to transverse plane motion of the hip.

Partial Squat. Pectineus muscle activation was low during maximum hip flexion because it has an internal rotation moment arm similar to the gluteal muscles [4]. However, the moment arms of the gluteal muscles change from internal rotation at deep flexion to external rotation as the hip approaches neutral extension in stance. The pectineus muscle has an internal rotation moment arm thus activation increases, as this muscle becomes antagonist to the gluteal muscles.

Gait. The pectineus muscle has a hip internal rotation moment arm throughout the gait cycle [1] and demonstrated maximum activation peaks during both maximum hip external and internal rotation. Further, the net hip torque was either external or internal at these maximum positions. Thus increased pectineus muscle activation was required to control the rate or extent of transverse plane motion at the hip.

Our results show that the pectineus muscle is active during hip internal and external rotation but it is unlikely that this muscle actively produced these motions. Activation of this muscle increased during weight bearing activity at the extreme transverse plane positions of the task or when the antagonistic hip external rotators increased activation. These results combined with the morphology and anatomic position of the pectineus muscle indicates that this muscle performed as a "dynamic ligament" that stabilized the hip in the transverse plane.

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