Frequency Characterization of Thigh Soft Tissue Artifact During a Relaxed and Activated State

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Marker-based motion capture systems are commonly used for biomechanical analyses to measure human movement by tracking the positions of reflective markers placed on the surface of the skin. A 3D model of the human subject can be created using the position data from the markers. This provides an approximate location of the position and orientation of the underlying bones during a particular movement. A well-known limitation of this method of data collection, however, is the relative movement of skin and other soft tissue over the bone known as soft tissue artifact (STA). In order to accommodate for this discrepancy, a low-pass filter at 6 Hz has been shown to be somewhat effective at removing STA and has been used as the typical low-pass filter. However, the frequency at which data should be filtered has been shown to depend on the movement type as well as various physical characteristics of human subjects.

For this study, the objective was to analyze how the STA frequencies of the thigh differ based on an activation state of the thigh musculature. Four subjects participated in the study, and reflective markers were placed on each subject using a 79 marker set based on the point cluster technique. The test consisted of subjects standing with their right foot on a platform, which was raised to a height such that the knee was at 90 degrees of flexion. The subjects were instructed to relax the thigh and perturb the skin by twisting the thigh with one hand about the femoral longitudinal axis to its maximum possible angle and quickly releasing, allowing the soft tissue to oscillate freely. The subjects were then asked to repeat the procedure, while activating the musculature of the thigh. Three trials were taken for both conditions on the right leg. The marker trajectories were processed in MATLAB® by creating an anatomical reference frame on the thigh and tracking movement of the centroid of the 9-marker thigh cluster relative to the origin of the segment. The angle of twist about the femur was calculated for each trial and converted to the frequency domain with a Fast Fourier Transform (FFT) to analyze the frequency components of the signal.

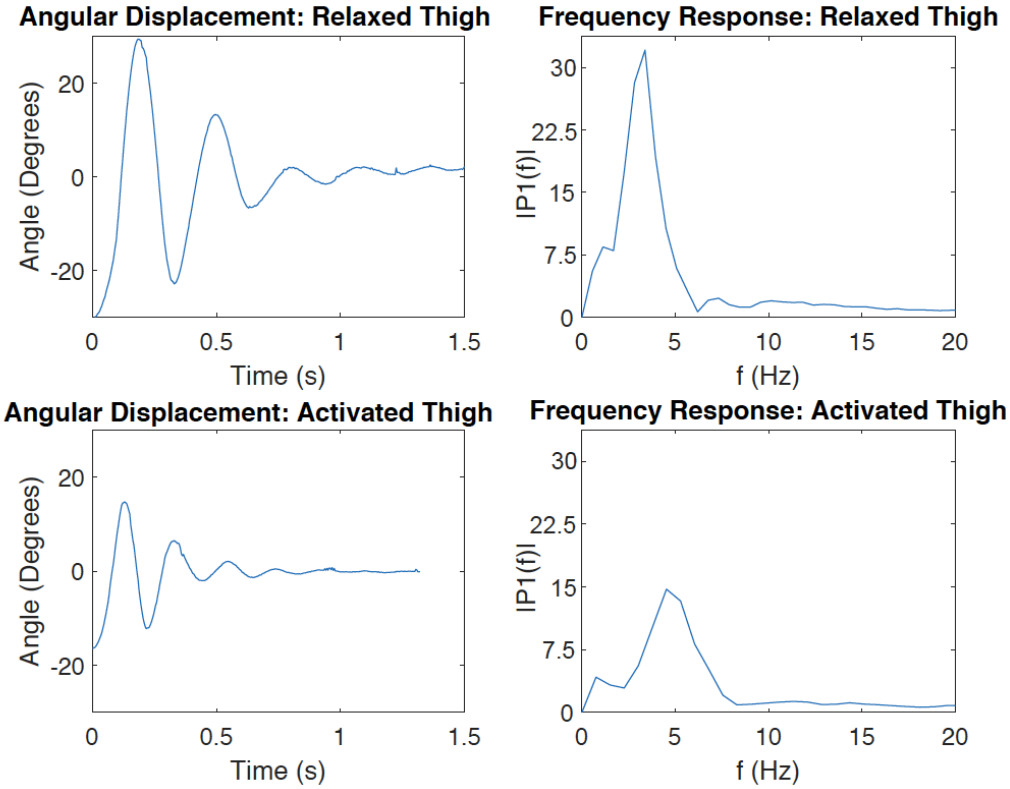

Figure 1. Time history and frequency response plot for a single subject with |P1(f)| = peak amplitude (deg).

The results indicated that the angular frequency of the thigh increased with muscle activation, where a relaxed and activated thigh had an average frequency of 4.04 and 5.60 Hz, respectively. More importantly, the average frequency is less than 6 Hz regardless of activation. This means that some STA might not be removed from motion capture data when the typical 6 Hz cut-off frequency is used. The results of this study have indicated the possibility of allowing STA into motion capture results while using a 6 Hz lowpass filter. Future work in determining the relationship between STA and physical traits of the subject, such as age, weight, sex, and percent body fat, is needed to further determine STA frequencies for various subject characteristics.

Statement of Research Advisor

Scot has done tremendous work that has determined thigh muscle oscillation frequency in a contracted and relaxed state for this group of subjects. These data are new to the field and have practical utility in improving biomechanical analyses dependent on surface-based motion capture markers.

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