

DIFFERENCES IN INTRAMUSCULAR EMG ACTIVITY IN ABLE-BODIED SUBJECTS AND TRANSRADIAL AMPUTEES DURING STRUCTURED HAND MOVEMENTS

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INTRODUCTION

Commercial myoelectric prostheses have limited capabilities to simultaneously control multiple degrees of freedom. These prostheses typically rely on signals recorded from surface EMGs placed on the residual limb, which are not the full set of extrinsic hand muscles required to actuate individual fingers. In addition, standard control approaches usually use pattern recognition or map muscle activity to specific prosthesis movements while largely ignoring underlying biomechanics. Understanding the coordinated activity of extrinsic hand muscles and how their activity results in individual joint movements across a wide range of hand configurations is an essential step towards improving the dexterity of prosthesis control. Here we use dimensionality reduction and clustering techniques to investigate these relationships in able-bodied subjects and an amputee.

METHODS

All procedures were approved by the University of Pittsburgh Institutional Review Board and the US Army Human Research Protection Office. Nine able-bodied subjects and one transradial amputee were recruited for this study. We recorded intramuscular EMG (iEMG) from 16 extrinsic hand muscles targeted using ultrasound. Subjects were instructed to attempt 45 movements that included individual finger and wrist movements in different wrist postures (flexed, extended, pronated, supinated and neutral). iEMG signals were recorded at 30 kHz, high-pass filtered at 20 Hz, rectified, and then low-pass filtered at 4 Hz. Principal component analysis (PCA) and hierarchical clustering analyses (HCA) were used to study EMG activity across the different movements and subjects.

RESULTS & DISCUSSION

We found a major difference in the number of principal components (PCs) required to explain 90% of the variance in the EMG data between the amputee (5 PCs) and able-bodied subjects (10- 11 PCs). In addition, HCA clustered the movement trials into four major subgroups consisting of wrist flexion/extension, wrist pronation/supination, wrist

adduction/abduction, and all fingers based on all 10 subjects' EMG activity patterns.

The differences in the number of PCs between able-bodied subjects and the amputee could potentially be explained by the reduced muscle set in amputees, challenges related to muscle targeting, or more interestingly, changes in the ability to voluntarily make certain movements as a result of the chronic limb loss. The HCA results can be used to help visualize and understand the underlying patterns of EMG activity. The results of this study can be used to inform the design of bio-inspired controllers that generate prosthesis control signals from the biomechanical function of the muscles and the resulting movement dynamics.