Quantifying the spatial distribution of individual muscle units using high-density surface EMG and ultrafast ultrasound

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INTRODUCTION:
Resistance training is a well-known intervention to improve muscle strength (1), with motor unit (MU) adaptation playing an important role (2). Recently, MUs were tracked in humans before and after resistance training using high-density surface electromyography (HDsEMG), showing a correlation between maximal force increase and MUs' average discharge rate (3). Although these results demonstrate the relationship between an increase in strength and MU activity, only MU-level neural adaptation was considered. Indeed, neural and muscular information needs to be studied jointly to understand the exact adaptations of the MUs in response to resistance training (4).
Recently, a method based on ultrafast ultrasound was presented, providing estimates of MU territories in cross-section and the train of twitches evoked by the spinal motoneurons' discharges (5). In this study, as a proof-of-concept, we combined ultrafast ultrasound and HDsEMG to explore the spatial distribution of individual MUs.

METHODS:
In a cross-sectional study, four participants performed low-force isometric contractions of the biceps brachii muscle while recording HDsEMG and ultrafast ultrasound signals from the biceps brachii muscle.
The HDsEMG signals were decomposed into individual MU discharge timings (6), and the ultrafast ultrasound signals were decomposed into many components, each having a spatial map and temporal signal (5). We matched each discharge timing of a MU with a component based on spike-triggered averaging of the component's temporal signal. Given a selected component, we applied a threshold to the spatial map and calculated the centroid and an equivalent diameter.

RESULTS:
Out of 16 recordings from four subjects, we decomposed 82 MUs from HDsEMG. Given this, we found 32 matches between individual MU discharges and ultrasound components where the triggered twitches had a significant amplitude. The estimated territories were 4.6 ± 1.1 mm (ranging from 2.8 to 8.6 mm), in line with findings from previous research using scanning-EMG (7). Moreover, the components were located 12.7 ± 3.4 mm below the skin (ranging from 6.4 to 19.4 mm).

CONCLUSION:
Our results show that using ultrafast ultrasound and HDsEMG in a strength training intervention, we should be able to quantify the relative contribution of the nervous system and skeletal muscle at the MU level. This information may provide the time course of both neural and hypertrophic adaptations to resistance training and elucidate the relative contributions of each to strength gain.

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