Background, Motivation and Objective

The interaction between muscle activation dynamics and the resulting mechanical muscle contraction is yet underexploited. Ultrafast ultrasound imaging (UUI) has been used for measuring electromechanical delay (EMD: time lag between onset of muscle electrical activity and force production [1]), as potential biomarker for the progression of neuromuscular disease, but reported values are conflicting [2], [3]. Moreover, propagation of Contractile Waves (ConWs) in response to propagating Action Potentials (AP) is neglected. Here we developed and evaluated a novel in vivo protocol to track electromechanical waves, as a potential novel biomarker, in muscle fibers with high spatiotemporal resolution by combining high density electromyography (HD-EMG) with UUI.

Statement of Contribution/Methods

Muscle contractions of the Biceps Brachii (BB) were evoked by percutaneous electrical stimulation (Micromed Energy: single pulse, duration 200 µs, current 2-5 mA). HD-EMG tracked the AP (Refa TMSi: 8×8 EMG grid). Signals along muscle fibers were bandpass filtered (3^{rd} order Butterworth 25 - 500 Hz) and spatially filtered (longitudinal single differential) to obtain bipolar EMG signals. Contractions were imaged with a L12-5 ultrasound probe placed directly on top of the EMG grid and connected to Vantage-256 (Verasonics; plane wave frame rate: 5000 fps). Axial tissue velocities were calculated using one-lag autocorrelation speckle tracking [4]. Velocities were low-pass filtered (10^{th} order Butterworth 150 Hz) and differentiated to obtain acceleration. Propagation velocities of AP (V_{ap}) and ConW (V_{conw}) were determined by a Radon transform [5] of EMG and tissue acceleration respectively. EMD ($D_{ap\text{-}conw}$) was defined as the mean delay between the depolarizing peak in AP and subsequent peak in acceleration (for each lateral position).

Expected tasks/outcomes

You are expected to reviel the literature on the relvant subject of tracking mechanical waves with ultrasound and gather all the existing methods. Then, implement them and test them on the existing data that we have acquired recently on volunteers to find out the pros and cons of the existing methods for such an application.

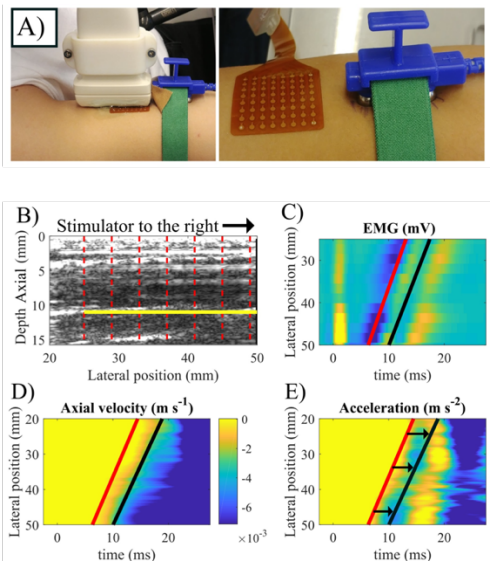

Fig. 1 Experimental setup and typical example of data, (**A**) EMG electrode, US probe and stimulation device on Biceps Brachii (BB), (**B**) Cropped US image of BB, dashed red lines denote bipolar center of EMG electrodes, ConW is tracked along the yellow line. (**C**) EMG signals from electrodes beneath US probe, (**D**) and (**E**) axial tissue velocity and acceleration along the yellow line. (**C-E**) Data along the yellow line over time, red line depicts AP arrival, black line first occuring peak in tissue acceleration after AP arrival at given lateral positions. Arrows denote delay between AP and ConW resulting in the delay in $D_{ap\text{-}conw}$.

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