USING EMG TO ESTIMATE FUTURE TORQUES ABOUT A JOINT
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AIM: It has long been known that peak EMG activity precedes peak mechanical tension by 50–100 ms or more. Hence, EMG should be able to estimate torque at future times, at least over this limited time scale. Thus, we systematically evaluated EMG-torque estimation about the elbow joint at future times ranging up to 750 ms, at a time increment of 5 ms.

METHODS: Previously collected EMG data from biceps and triceps muscles of 54 healthy subjects were reanalyzed. The contractions were constant-posture and force-varying. The EMG signal was optionally whitened and then related to torque via an optimized linear model or an optimized nonlinear model. Performance was assessed vs. the time advance of the torque signal.

RESULTS: Higher-order, whitened, nonlinear models exhibited a prediction error minimum of 5.48 ± 2.21 %MVC_F (percent flexion MVC) over the time advance range from 0–60 ms, with error growing for larger time advances. Performance of our optimal filters was compared to the common second-order Butterworth filter approach. This filter produced a statistically inferior average error of 6.90 ± 2.39 % MVC_F, and only at a time advance of 60 ms. Error grew on either side of this nadir.

CONCLUSION: Torque in the elbow could successfully be estimated up to 60 ms into the future, without change in performance, using optimized EMG-torque models. Butterworth models performed poorer and only at one specific time delay—perhaps indicating why some authors add a pure time delay to Butterworth-type models. Our optimized models performed better and do not require the cascade of a pure time delay.

Figure 1: EMG-torque results for the optimal linear model, optimal nonlinear model and the second-order Butterworth model, averaged across 54 subjects, for time delays between 0–750 ms.