

KINEMATIC AND EMG VARIABILITY WHILE PRACTICING A MAXIMAL EFFORT TASK

David A. Gabriel

Biomechanics Lab, Brock University, St. Catharines, ON L2S 3A1

E-mail: dgabriel@arnie.pec.brocku.ca

INTRODUCTION

This paper explores changes in the variability of surface electromyographic (EMG) activity and kinematics associated with practicing a maximal performance task. The variability of muscle force-impulses producing movement is proportional to the mean size of the impulse (Schmidt et al. 1979). Since increases in limb speed require larger accelerative and decelerative force-impulses, movement variability increases due to an increase in the variability of the muscle force-impulses. If, however, antagonist muscle activity can compensate for variations in agonist muscle activity, movement variability does not necessarily increase (Darling and Cooke, 1987). This paper determined how changes in the variability of EMG activity result in a decrease in kinematic variability subsequent to practicing a maximal performance task.

METHODS

Eight subjects (aged 25 to 30 years) gave their permission to participate in this study. With the elbow in full extension, subjects rotated their forearm as fast as possible to reach a target corresponding to 80° of elbow flexion. The target area was $\pm 1.5^\circ$ around the specified joint position. Subjects monitored elbow flexion angle relative to the target area on an oscilloscope. All movements were performed in the horizontal plane on a manipulandum. One hundred trials were completed on each of four practice sessions. The data were collected

for the first five (1-5) and the last five (96-100) trials of each practice session.

Angular displacement and EMG activity of the biceps and triceps (lateral head) brachii were monitored concurrently. The EMG activity was amplified (5000 \times) and band-passed (3-1000 Hz) with a Grass P-511. All signals were digitized at 2 kHz, and stored on a hard disk for off-line processing. The EMG was then low-passed at 60 Hz with a zero-phase second-order Butterworth digital filter. The displacement signal was similarly low-pass filtered at 10 Hz.

Three measures were calculated for the first five (1-5) and last five (96-100) trials of each practice session. Peak velocity was obtained from the differentiated displacement curve. Trajectory (velocity versus position) variability was calculated from the area of ellipses with radii equal to one standard deviation in velocity and position at each point (SD^2). The coefficient of variation in biceps and triceps brachii EMG magnitude. A repeated measures analysis of variance was used to evaluate any change in these measures. Post-hoc testing was accomplished using Tukey's (HSD) test.

RESULTS

The data presented in Figure 1 is organized so that Block 1 is the mean of the first five (1-5) trials and Block 2 is the mean of the last five (96-100) trials of Session 1. This continues so that Block 8 is the last five (96-100) trials of Session 4 for a total of four hundred trials.

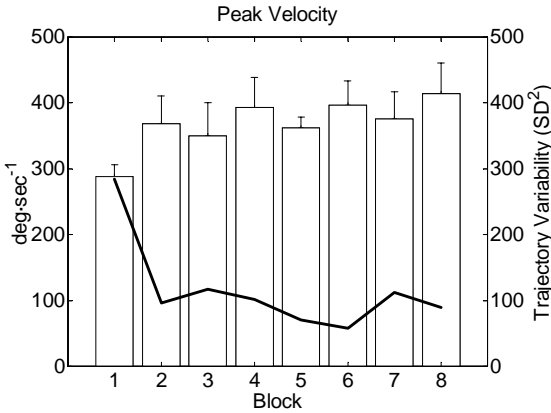


Figure 1. Peak velocity (bar: left y-axis) and trajectory variability (line: right y-axis).

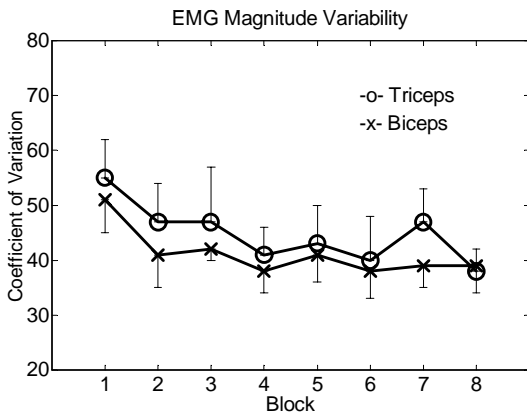


Figure 2. The coefficient of variation in biceps and triceps EMG magnitude.

Peak velocity increased 127-deg·sec⁻¹ (44%) across the four practice sessions ($p < 0.05$). There was a dramatic decrease ($p < 0.05$) in trajectory variability of 186 SD² (66%) between the first five (1-5) and last (96-100) trials of Session 1, but it remained stable thereafter. The relative variability of the individual EMG bursts also decreased. Figure 2 shows that the coefficient of variation in biceps and triceps EMG magnitude exhibited a total decrease of 31 and 23%, respectively ($p < 0.05$). Similar to trajectory variability, most of the change occurred early in the measurement schedule.

DISCUSSION

Kinematic variability decreased, but not because of a linkage between agonist and antagonist activity as suggested Darling and Cooke (1987). Rather, there was a decrease in the variability of muscle activity. Since angular acceleration is proportional to joint torque in single-joint movements, there should be a clear relationship between kinematics and EMG activity. A reduction in the variability of EMG magnitude should therefore result in a decrease in trajectory variability.

Decreased variability is a property of programmed movements (Georgopolous et al. 1981). The EMG and trajectory data suggest that practice resulted in greater central nervous system control over both the spatial-temporal aspects of movement and the magnitude of the biceps and triceps muscle force-impulses. This supports Moore and Marteniuk (1986) who also reported a decrease in EMG variability following practice. The authors suggested that practice shifted the generation of EMG activity to a higher level in the motion planning hierarchy though it is still subordinate to kinematics.

REFERENCES

- Darling, W.G., Cooke, J.D. (1987). movements. *J. Motor Behavior*, **19**, 311-331.
- Georgopolous, A.P. et al. (1981). *J. Neurophysiology*, **46**, 752-743.
- Moore, S.P., Marteniuk, R.G. (1986). *J. Motor Behavior*, **18**, 397-426.
- Schmidt, R.A. et al. (1979). *Psychological Review*, **86**, 415-451.