INTRODUCTION

Muscular forces produced during maximum voluntary contractions are typically 3-20% smaller during simultaneous bilateral exertions than during independent unilateral exertions. This result describes the traditional manifestation of the bilateral deficit phenomenon. However, there is evidence to suggest that bilateral deficits may also exist for motor tasks performed at submaximal intensities (Oda & Moritani, 1996; Seki & Ohtsuki, 1990). The purpose of this experiment was to test the hypothesis that a significant bilateral deficit in isometric elbow flexion force would be found at both maximal and submaximal intensities. It was expected that any reductions in simultaneous bilateral force would be paralleled by reductions in agonist EMG activity and would not be associated with increases in antagonist EMG activity.

PROCEDURES

Twenty right-handed college students volunteered to participate in the experiment (mean age 23.2 ± 3.9 yr., height 168.6 ± 9.5 cm, and mass 71.9 ± 13.0 kg). Isometric elbow flexion force data were obtained from each arm separately using two independent strain gauges. Bipolar surface electrodes were used to measure EMG activity of the biceps and triceps on each arm. Force and EMG data were sampled for 3 s at 1000 Hz. Subjects completed a series of maximum effort elbow flexion tasks, which were followed by a series of submaximal exertions at 25%, 50%, and 75% of their perceived maximum effort. Subjects received no feedback regarding the actual levels of force that were produced. All exertions were performed unilaterally with the right (RUL) and left arms (LUL) separately, and bilaterally with both arms together (BL). Three trials were completed for each condition and for each intensity level. Maximum and submaximum elbow flexion forces were defined by the average force in a 250 ms window that resulted in the greatest integrated force and minimum RMS error values, respectively. Average integrated EMG (AIEMG) values were quantified over the 250 ms windows that were defined by the force-time criteria. For each subject and for each arm, relative forces were expressed as percentages of either the UL maximum or mode (UL or BL) maximum. Bilateral deficits in relative force were calculated using the bilateral deficit index (Howard & Enoka, 1991).

\[ \frac{(RBL+LBL)}{(RUL+LUL)} \times 100 - 100 \]

RESULTS AND DISCUSSION

Bilateral deficits in force were observed at both maximal and submaximal intensities (Fig. 1). A 2x2x4 repeated measures ANOVA of the isometric force data revealed significant main effects \( p < .05 \) between arms \( (L < R) \), modes \( (BL < UL) \), and levels \( (25% < 50% < 75% < 100%) \). Doubly-multivariate repeated measures analyses of variance of both triceps and biceps AIEMG data revealed significant differences between levels. However, despite trends to the contrary (Fig. 2), AIEMG were not different between modes (biceps, \( p = .12 \); triceps, \( p = .06 \)).
Bilateral forces were significantly less than unilateral forces across maximal and submaximal intensities. When all forces were expressed as percentages of UL maximum forces, bilateral deficits ranged from -18.3% at 25% max to -11.4% at 100% max. When forces were expressed as percentages of either the UL or BL mode maximum, bilateral deficits ranged from -8.1% at 25% to 0% at 100% max. The difference between these relative expressions of UL and BL force was nearly constant (-11%) across intensity levels (Fig. 3) which indicated that a significant component of the bilateral deficit was independent of consciousness. The remaining component of the bilateral deficit, indicated by the deficit band on the % mode maximum data, was attributable to perceptual differences between UL and BL tasks. The magnitude of this "perceptual" component was inversely related to the level of intensity and therefore contributed more significantly to the bilateral deficit at lower submaximal intensities.

In conclusion, the bilateral deficit appears to be manifest at both maximal and submaximal intensities. At decreasing submaximal intensities, perceptual differences between unilateral and bilateral exertions appear to contribute significantly to the magnitude of the bilateral deficit phenomenon.

REFERENCES