TRIPHASIC PATTERNS IN ABOVE-ELBOW AMPUTEES

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INTRODUCTION

In normally limbed humans, voluntary fast elbow movements produce triphasic myoelectric activity patterns in the biceps and triceps muscles. The first phase, or burst, occurs in the agonist muscle (AG1) and represents the angular acceleration of the lower arm. The second burst occurs in the antagonist muscle (ANT1) and represents the angular deceleration of the lower arm [7]. The third burst occurs again in the agonist muscle (AG2), and is believed to represent a correction mechanism that moderates the braking forces and redirects movement back to the target position [10]. Triphasic patterns have, for the most part, been found to be preprogrammed and generated by the central nervous system [2,9]. This central preprogramming suggests that phasic patterns might still be observed after amputation, even though the mechanical function of the remnant muscles is lost.

METHODS

Subjects were asked to perform identical, fast, short elbow flexion and extension movements simultaneously with both arms (using imagined movements, where appropriate). Each had been fitted with four Boston Elbow electrode amplifiers, one placed over the biceps and one over the triceps of each arm. The subjects were standing, and the two types of elbow movement were initiated from different positions of the arm: flexion from a relaxed position (arm hanging down next to the body); and extension from a bent-elbow position of approximately 90° (forearm parallel to the floor). Each subject was continuously urged to perform the desired movement with both arms simultaneously, as rapidly as possible over a short angle distance of approximately 45°.

Five normally limbed subjects were tested to investigate how arm-dominance influences the patterns in the biceps and triceps muscles. Ten unilateral above-elbow amputees were asked to perform the same movements, to allow comparison of the muscle patterns from their sound and amputated limbs. Of the ten amputee subjects, seven had lost an arm traumatically, and thus had previously possessed normal motor control of the amputated arm. The other three were congenitally limb-deficient. All ten amputees retained a normal set of biceps and triceps in the remnant limb.

RESULTS

Arm dominance was found to cause only small differences in triphasic muscle patterns and was not considered an important influence on the data acquired from the amputees (figure 1). All traumatic amputee subjects showed bi- or triphasic patterns in both arms during elbow flexion. However, the timing and duration of the individual bursts differed between the sound and amputated arms. These differences were inconsistent among subjects and movement types (figures 2 and 3). In addition, only three of the seven traumatic amputees showed phasic patterns in the remnant muscles during elbow extension. The other four produced co-contractions, the cause of which is yet unclear. The congenitally limb-deficient subjects had never possessed a lower arm, so phasic patterns were neither anticipated nor found during elbow flexion or extension (figure 4).

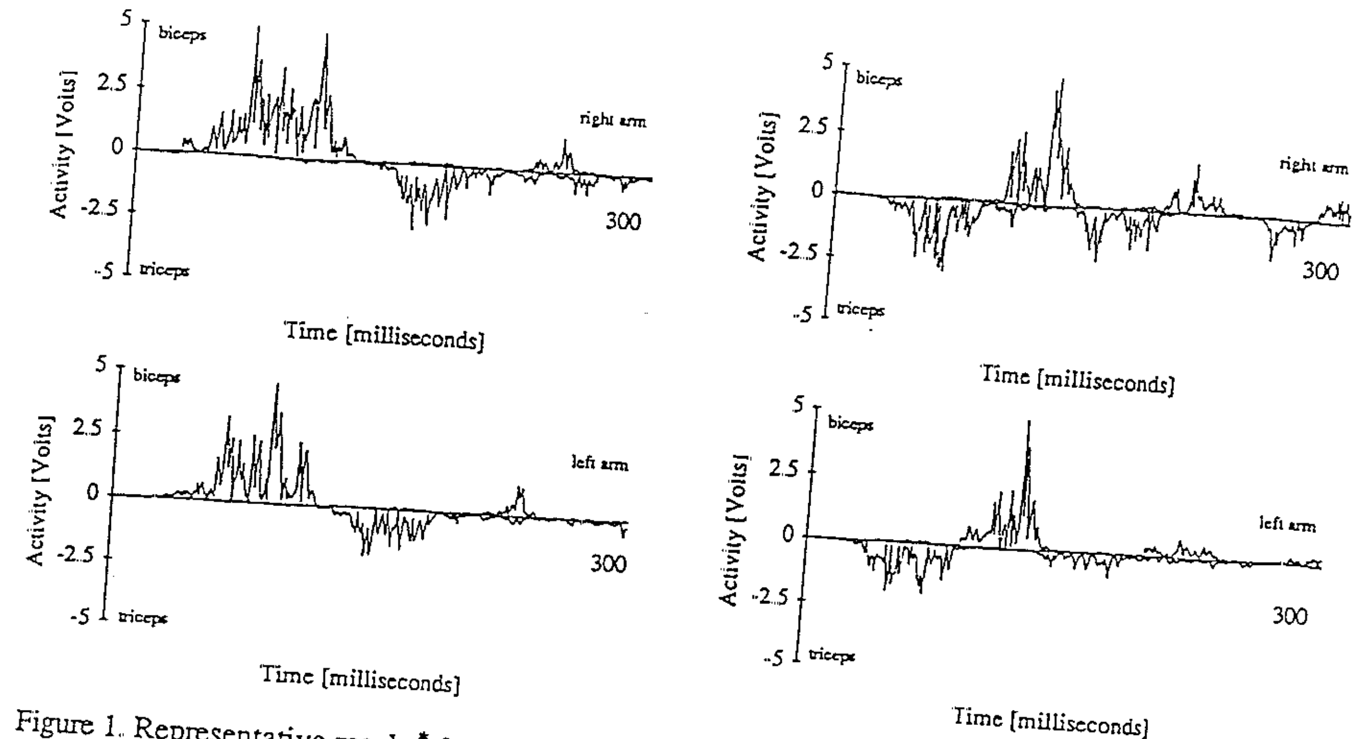

Figure 1. Representative results* from Normal Subject 5 (right dominant).

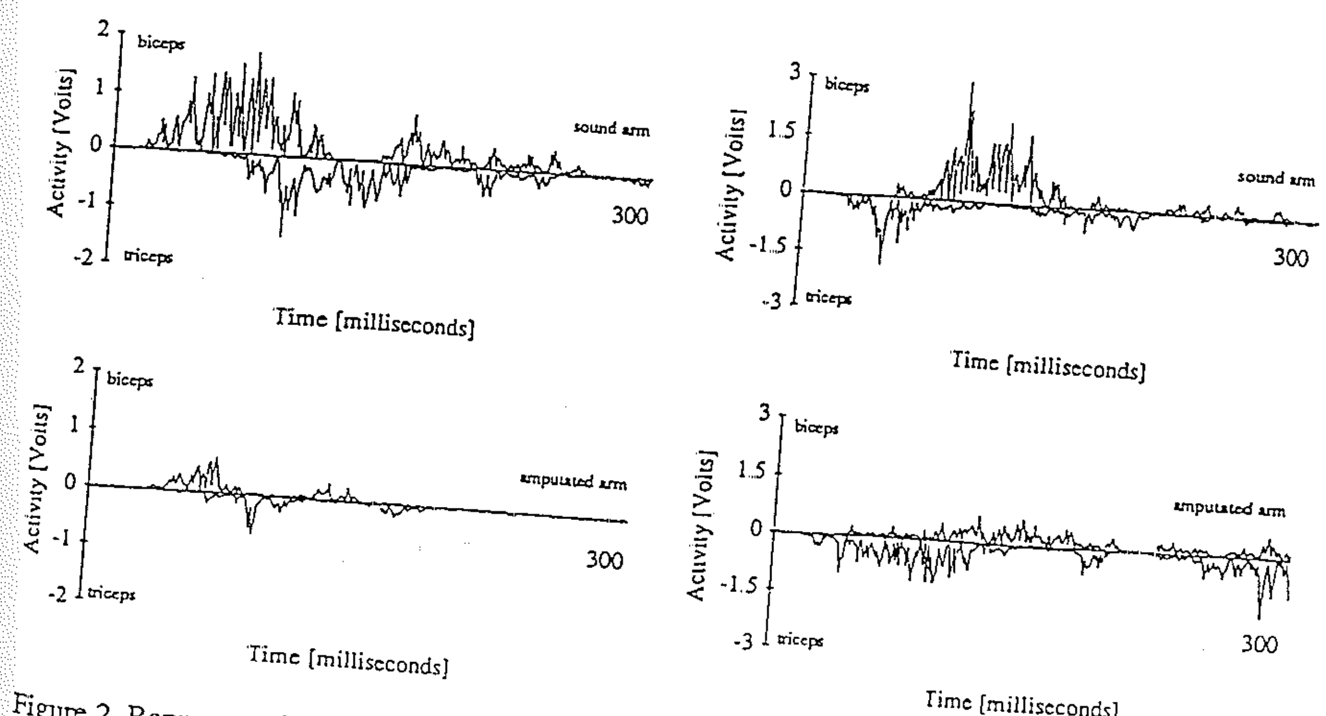

Figure 2. Representative results* from Traumatic Amputee Subject 8.

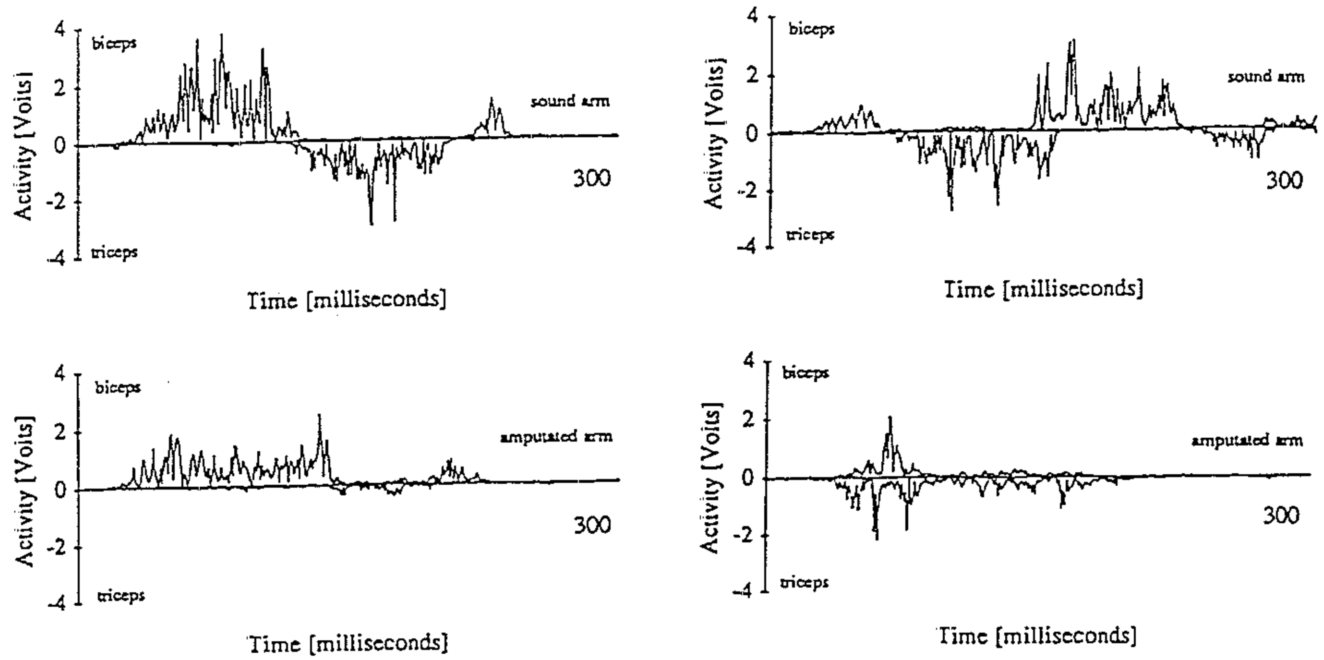

Figure 3. Representative results* from Traumatic Amputee Subject 9.

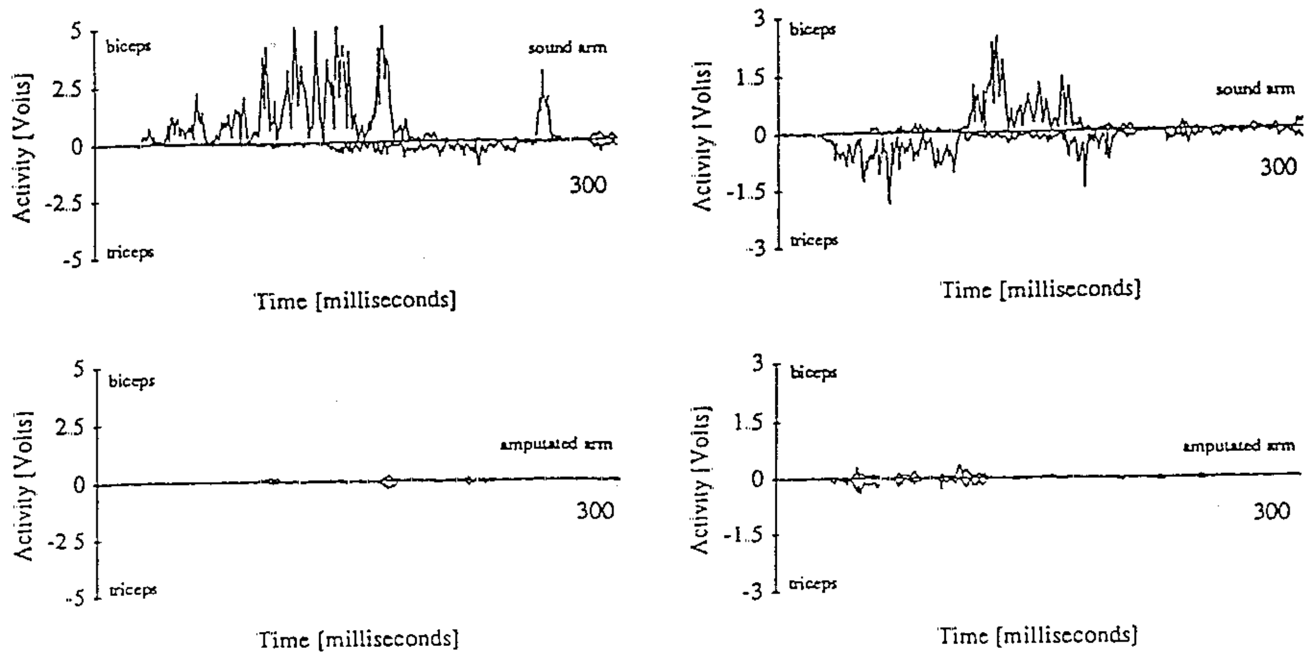

Figure 4. Representative results* from Congenital Amputee Subject 15.

Only the cause of amputation showed a clear relationship with the measured patterns. The traumatic amputees produced phasic patterns in the remnant limb, while the congenitally limb-deficient subjects did not show these patterns. No other parameter showed clear correlation with the measured muscle activities. The number of years since amputation (subject range: 0.5 to 46 years) and the length of the remnant limb (subject range: 7 cm to elbow length) did not seem to be influential. Phasic patterns and/or co-contractions during elbow extensions were found to occur both in amputees who did and did not use a myoelectric prosthesis. Subjects who had never experienced phantom sensations were equally as adept at producing phasic patterns as subjects with strong phantom-limb sensations.

DISCUSSION

These data suggest that traumatic amputees might find it more natural to control a myoelectric prosthesis in a manner that mimics control of a sound limb. Since amputees want to engage in normal movements without attracting attention, the choice for this type of strategy seems even more obvious. From this point of view, the impedance control scheme of Abul-Haj and Hogan [1], which closely mimics the characteristics of the intact neuromuscular arm system, shows significant promise. However, this may not be suitable for congenitally limb-deficient individuals. In those cases, it is believed that research into other myoelectric approaches that do not maximally relate to normal arm movement control [3,4,5,6,8] may be more appropriate.

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* The left two graphs show a fast, short elbow flexion. The right graphs show a fast, short elbow extension.