ELECTROMYOGRAPHY OF TRUNK MUSCLES DURING WHEELCHAIR PROPULSION

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INTRODUCTION

Paralysis of the primary trunk musculature likely contributes to ineffective force application during wheelchair propulsion [1]. Functional electrical stimulation (FES) as a modality to improve trunk posture, balance and propulsion efficiency in persons with spinal cord injury is currently under investigation. In order to implement an effective stimulation pattern during propulsion, an understanding of the muscle activation patterns of core trunk musculature is necessary. Therefore, the purpose of this study was to establish and describe muscle activation profiles of selected back and abdominal musculature during wheelchair propulsion using surface electromyography (EMG).

METHODS

Subjects: Fourteen unimpaired subjects (12 male and 2 female) provided informed consent prior to participation in the study. The average age, weight and height were 24.7 ± 3.6 years, 69.3 ± 14.3 kilograms and 1.73 ± 0.07 meters respectively.

Experimental protocol: Bipolar, surface electrodes (Noraxon Inc., Scottsdale, AZ) were placed over three abdominal muscles (rectus abdominis: RA, external oblique: EO and internal oblique: IO), and three back muscles (longissimus thoracis: LT, iliocostalis lumborum: IL, and multifidus: MU). Prior to the propulsion trials, ten seconds of maximum voluntary contraction (MVC) EMG data were recorded during maximal effort exercises for normalization purposes. Subjects were asked to propel at a steady-state speed of 1.8 m/s for 20 seconds using a test wheelchair which was fitted bilaterally with a SMART^{Wheel} (Three Rivers Holdings, LLC., Mesa, AZ), and secured to a computer-controlled dynamometer with a four-point tie down system. Real-time propulsion speed was displayed on a computer screen in front of the subjects. A three-dimensional motion analysis system (Northern Digital Inc., Ontario, Canada) was synchronized with the SMART^{Wheel} and EMG system to record kinematics of the upper limbs, propulsion forces and EMG activity during propulsion.

Data analysis: EMG data were sampled at 1000 Hz, full wave rectified and smoothed with a 10-Hz low pass filter. EMG voltages during propulsion were normalized as %MVC for each muscle. Significant EMG activity was defined as activity with an intensity of at least 5% MVC and for longer than 5% of the propulsion cycle (PC). In order to compare muscle activity across subjects, the time of the PC was normalized to 100% and the push phase to 45% of the cycle for each subject (mean push percentage for the groups). The push phase was further divided into early push (0%–2% of PC) and late push (2%–45% of PC), and recovery was separated into 3 subphases [2] of follow-through (45%–53% of PC), hand return (53%–97% of PC), and pre-push (97%–100% of PC) according to hand motion during an entire PC.

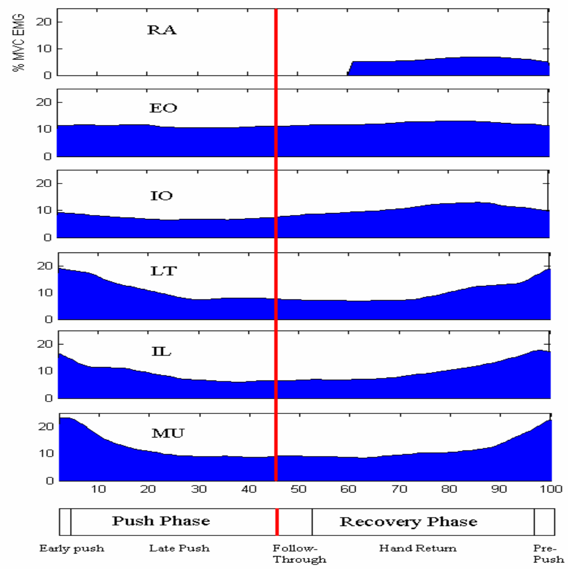

Figure 1: The mean EMG profile of trunk muscles during a propulsion cycle at speed of 1.8 m/sec

RESULTS AND DISCUSSION

During pre-push and early push phases, abdominal muscles (RA, EO and IO), and back muscles (LT, IL, and MU) were active and contracted to provide stability for the trunk while delivering forces to the pushrim (Figure 1). While delivering forces to the rim during late push phase, back muscle activity declines allowing the trunk to lean forward in pushing. During recovery phase (follow-through/hand return), back muscle activity gradually increased to move the trunk upright and abdominal muscles activated to prepare for the next stroke in the late phase of hand return and pre-push.

CONCLUSIONS

Our findings indicate that back and abdominal muscles both showed high activity levels during the pre-push and early push phase. This synchronized activation may provide trunk stability and prevent the trunk from moving in opposition to the arms when applying forces to the pushrim [3]. Researchers can use this profile of trunk muscle activation to develop a muscle stimulation pattern that will increase trunk stability and improve propulsion efficiency of manual wheelchair users with spinal cord injury.

REFERENCES

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