Alterations to EMG Onset After Utilization of Foot Drop Stimulator (FDS)

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Abstract— **The purpose of the this investigation was to evaluate the secondary benefit of FDS on spasticity and motor control at the knee for a child diagnosed with CP. We hypothesized that the secondary benefits of FDS would produce a decrease in knee spasticity and an improvement in motor control as measured by an increase in peak EMG amplitude and a decrease in the delay between the onset of agonist EMG activation and the start of knee extension. The main purpose of the FDS is to correct foot drop in children with cerebral palsy. Peak EMG amplitude and EMG onset data of agonist muscles (rectus femoris (RF); vastus lateralis (VL)) and antagonist muscle (biceps femoris (BF)) were examined for one male subject (11 years of age) diagnosed with cerebral palsy. Results show a reduction in the time delay between the onset of the agonist muscular activation and the onset of knee angular position, as well as an increase in peak EMG amplitude. Additional research with a larger number of children is needed to confirm results of this investigation.**

Keywords— spasticity, motor control, knee joint, foot drop, cerebral palsy. electromyography, EMG onset, EMG amplitude.

I. INTRODUCTION

There are approximately, 500,000 individuals in the United States with spasticity including children and adults with neuromuscular disorders (cerebral palsy (CP), traumatic brain injury and stroke) and spasticity is commonly seen in children with CP [1, 2]. Individuals with CP also may experience hemiplegia, contractures, imbalances in muscle control and muscle weakness. Many children who experience muscle weakness in the lower extremities, also present with foot drop and secondary gait related complications [4, 5]. Despite this muscle weakness, approximately 70% of individuals with CP are able to ambulate during childhood but often with decreased functional ability and difficulty ambulating in the community or at school [3]. Foot drop stimulators (FDS) have been prescribed to correct foot drop in children with neurological disabilities including CP [11]. FDS includes the delivery of electrical impulses to a nerve or several nerves that results in the contraction of a specific muscle or group of muscles [9, 10]. Current clinical goals for children with CP often focus on reducing spasticity and treating the secondary complications during ambulation.

The secondary benefits of FDS treatment may include a reduction in spasticity at the ankle and knee joints [12]. A reduction in spasticity could provide an improvement motor control at the affected joints. In the current investigation we evaluated a passive/quasi-passive motion at the knee after 3 months of FDS use while walking in the community.

The purpose of this investigation was to evaluate the secondary benefit of FDS on spasticity and motor control at the knee for a child diagnosed with CP. We hypothesized that the secondary benefits of FDS would produce a decrease in knee spasticity and an improvement in motor control as measured by an increase in peak EMG amplitude and a decrease in the delay between the onset of agonist EMG activation and the start of knee extension.

II. METHODOLOGY

A. Participant

An 11 year old male with CP, right side hemiplegia, and foot drop was prescribed and FDS (WalkAide, Innovative Neurotronics Inc, Austin, Texas) with the aim of reducing his foot drop through daily utilization of the device. Data was collected at baseline, and after 3 months of use in the community. During data collection, the subject assumed a supine position on an examination table, as explained in a previous study [12]. The subject was then asked to actively move their shank from a neutral vertical position, to full extension, and then back to the neutral vertical position. Retroreflective markers were placed on anatomical landmarks on the lower extremities, and EMG data were collected from three muscles: rectus femoris (RF); vastus lateralis (VL); and biceps femoris (BF). Kinematic data were collected at 60Hz (Motion Analysis, Inc., Santa Rose, CA, USA), and time synched with wireless EMG data collected at 2520 Hz (Noraxon, Inc., Scottsdale, AZ, USA).

B. Data analysis

EMG data were filtered using a band pass filter (zero-lag, 4th order Butterworth; cut-off frequencies of 10 and 200 Hz). EMG data were then rectified and a linear envelope was generated. Detection of the onset of muscle activation and the start of knee extension was performed by using the mean of the first 700 samples of data (while the muscles are relaxed) plus 3 standard deviation as a threshold.

III. RESULTS

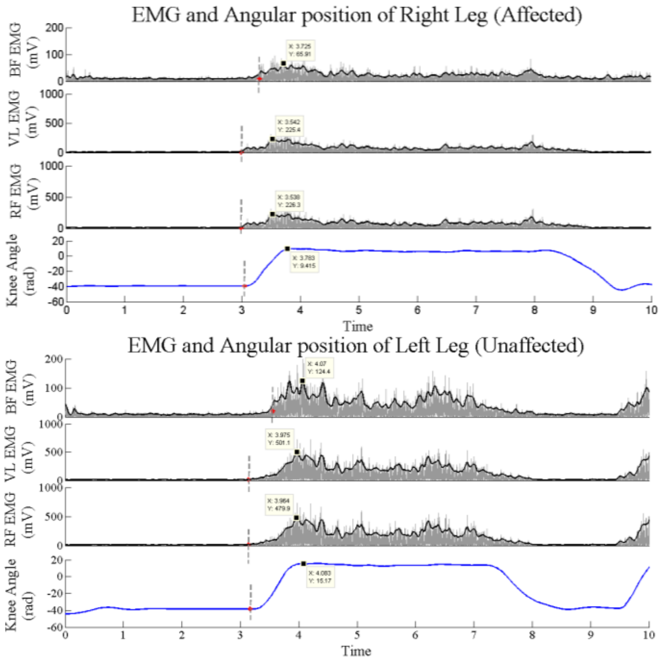

Fig. 1: Baseline data for the affected and unaffected side of the active knee movement from vertical zero position to full extension and back to vertical zero along with EMG from agonist (VL and RF) muscles and antagonist muscle (BF). The red dots are indications of the detected onset of EMG activation or the start of knee joint motion.

Table 1. Time delay between onsets of EMG and the start of knee extension, Modified Ashworth Scale, and peak EMG amplitude at baseline and 3 months

Muscle direction	Side	Muscle	Time delay (sec) EMG(sec) – Angle(sec)		MAS (Knee)		EMG peak Amplitude (mV)	
			Baseline	3 months	Baseline	3 months	Baseline	3 months
Agonist	*Affected*	VL	-0.0504	-0.0306	0	0	225.4	448.9
		RF	-0.0504	-0.0306			226.3	459.8
Antagonist		BF	0.2671	1.0948	1+	1	65.9	76.22
Agonist	*Unaffected*	VL	-0.0214	-0.0210	0	0	479.9	556.1
		RF	-0.0214	-0.0210			501.1	531.5
Antagonist		BF	0.3889	0.2865	0	0	124.4	63.6

IV. DISCUSSION

Data presented in this investigation suggests that utilization of FDS may not only have the effect of correcting foot drop during ambulation but may also lead to secondary benefits, including a reduced delay between the onset of agonist muscle activations and onset of knee extension. This improvement also correlates with a reduction in the level of spasticity as shown by the MAS, and an increase in peak EMG amplitude (Table.1) after three months of FDS usage. The combination of the reduction in the delay between the activation of agonist muscles and the start of volitional knee extension, and the increase in peak EMG amplitude, may suggest rehabilitative and functional improvements that could translate into a more efficient gait.

There are many different avenues which are opened for future research as a result of this study. In particular, the development of a more comprehensive assessment of spasticity, which should include an evaluation of the activation of the agonist and antagonist muscles in addition to quantifying other spasticity measures of a particular joint. This approach may also allow for a better understanding of the crucial differences between the neural and non-neural contributions to joint motion, specifically in the case of patients with increased level of spasticity.

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