MYOELECTRIC ELBOW-WRIST-HAND ORTHOSES (MEWHO) USED TO RESTORE FUNCTION IN A WEAK UPPER EXTREMITY RESULTING FROM CHRONIC STROKE - A CASE STUDY REPORT

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ABSTRACT

Every year in the U.S. approximately 795,000 people, (civilians, active military and veterans) experience a stroke. Approximately 40% of that group exhibit chronic disability including upper extremity (UE) impairments such as paresis and spasticity. Additionally, within the military, 33,149 U.S. personnel were diagnosed with a TBI in 2011 alone. For those survivors who undergo traditional rehabilitative therapies, they may frequently be left with chronic upper extremity impairments and an associated loss of function, dependence on caregivers and decreased quality of life. Custom fabricated myoelectric orthoses may provide an alternative solution to improve function and an adjunct to traditional therapies for those with hemiparesis and loss of UE function. It is the aim of this case report to describe the experience and assistive and rehabilitative outcomes of a veteran with one such custom myoelectric orthosis.

The myoelectric brace used for this case study is called the MyoPro. The Myopro® (Myomo Inc. Cambridge MA) is a custom fabricated myoelectric elbow-wrist-hand orthosis (EWHO) currently on the market for civilians as well as numerous VA facilities across the United States. Surface sensors - built into the orthosis and located over the upper arm and forearm muscles - detect the user's electromyography (EMG) signal once he/she initiates a muscle contraction. The EMG signal activates the motors on the orthosis to move the elbow or hand in the desired direction, proportional to muscle output.

CASE DESCRIPTION

The participant is a 62 yr. old veteran, who served in the Marines as a Corporal and in the Navy as a Seaman and is a recipient of a Purple Heart. He is a right hand dominant male who presented with dysarthria and left hemiplegia on 12/2/2013. Past medical history is positive for hypertension, tobacco use, a previous transient ischemic attack in 2010 and hyperlipidaemia. The participant began traditional outpatient occupational therapy (OT) in January 2014 to treat the functional deficits associated with his left hemiparesis, and was prescribed a custom myoelectric EWHO (without grasp capability) in April 2014. The patient met the criteria for the myoelectric EWHO including intact cognition, no UE contractures and sufficient EMG signal strength in his bicep and triceps to power the orthosis. Measurements and a cast were taken of his affected arm and a custom myoelectric EWHO was manufactured. The participant continued to participate in OT with his orthosis until August 2014, at which point he was re-evaluated for the advanced model that includes additional myoelectric grasp capabilities. The participant received his upgraded custom myoelectric EWHO in November 2014. At this time, the overall fit and comfort of the device was assessed, appropriate sensor locations were found and the device was programmed with the appropriate level of assistance using the manufacturers programming software. At the time of starting to use the myoelectric EWHO with grasp, the participant presented with unresolved UE deficits with range of motion, strength, fine and gross motor skills and functional use of the paretic left arm.

METHODS

The participant completed a total of 21, 1 hour outpatient OT sessions that began with traditional OT interventions for 3 months, such as functional electrical stimulation, mirror therapy, dynataping, massage wand, fluidotherapy, proprioceptive neuromuscular facilitation, therapeutic exercise, active-assisted and passive range of motion and task oriented/occupation based interventions, and then incorporated the custom myoelectric EWHO without grasp after it was delivered. The participant received training in proficient use of the orthosis: donning/doffing technique, repetitive task practice drills and application of the orthosis during multi-step functional tasks. He was also given a home activity plan and a wearing schedule, beginning at 30mins daily, in order to build up endurance and facilitate functional use of his affected extremity. After upgrading to the custom myoelectric EWHO with grasp, the participant completed an additional 14 sessions under the supervision of his therapist and fitting prosthetist, dedicated to mastering the operation of the myoelectric EWHO with grasp and utilizing it during daily functional tasks. A functional training protocol from the myoelectric EWHO manufacturer was incorporated at this time. Outcome testing throughout treatment included ROM (range of motion) testing, strength (Manual Muscle Testing), MAS (Modified Ashworth Scale) to assess spasticity and functional task assessment/observation. Once the participant upgraded to the myoelectric EWHO with

grasp, the Fugl Meyer assessment was also utilized to quantify progress.

RESULTS

Active left upper extremity ROM and strength both increased significantly (Table1 ROM, Table 2 Strength). He also demonstrated an improved ability to incorporate his affected extremity (while wearing his orthosis) into a wide variety of bilateral, gross motor ADLs and IADLs such as carrying a laundry basket (Photo 1), lifting heavy objects (e.g. a chair), using a tape measure, meal preparation and opening doors.

Photo 1

These results demonstrate how working with a custom myoelectric EWHO resulted in remediation of UE deficits, in particular wrist and hand function. Functionally, the participant demonstrated substantial improvements in daily use of his paretic left arm, and an increase in his overall level of independence and function at home and in his community. While wearing the myoelectric EWHO, the participant was able to use his left arm to carry weighted objects bilaterally, to stabilize objects such as a cup or plate and to put items away in overhead cabinets. He also demonstrated independence with household chores such as laundry, meal preparation and light cleaning tasks. Information from the manufacturers' survey and home log (September 2015 – March 2016) show that the participant was able to complete tasks such as sweeping/mopping the floor, washing and folding clothes and moving/lifting chairs. During this 6 month timeframe, the participant logged 25 entries and wore his myoelectric EWHO at home for a total of 34 hours during that time. The participant wore his myoelectric EWHO between 30 mins – 2 hours each time and reported an average satisfaction rating of 8.78/10 (0 = not satisfied at all, 10 = extremely satisfied). Overall, the participant reported a high level of satisfaction, improvement in his quality of life and increased functionality of his paretic arm. He also reported a few areas for improvement. These included addressing technical glitches with the sensors and electronics, decreasing the weight and bulk of the myoelectric EWHO (4lbs); redesigning the harness, increasing the battery life and making the myoelectric EWHO waterproof so he could wear in wet conditions. Battery life and fatigue were the most common reasons for needing to stop use of the myoelectric EWHO. The participant was able to self-don his myoelectric EWHO independently in 3-5 minutes, but he did express the need to practice and that it was difficult when he first tried to do it alone. Interestingly, the participant noted that if he stops using his myoelectric EWHO for longer than 2 days, his arm – in particular his hand and fingers – start to stiffen, loose ROM and function.

Table 1 ROM

	May 2014 (MyoPro Classic)	Sept 2014	Nov 2014 (MyoPro Motion G)	Jan 2015	March 2015	May 2015	March 2016
AROM (degrees)							
Shoulder flex	91 (supine)	133 (supine)	120 (seated with compensation)	120 (seated with comp)	155	WFL	WFL
Shoulder abd/add	90 (supine)	105 (supine)	82 (seated with compensation)	82	120/ Full	WFL	WFL
Elbow flex	97 (seated)	WFL (supine)	125 (seated)	125	130	WFL	WFL
Elbow ext	-30 (seated)	WFL (supine)	-20 (seated)	-20	0	WFL	WFL
Supination/ Pronation	NT	NT	60/40	NT	60/full	NT	NT
Wrist flex	20 with gravity assist	20	20	35	40	55	NT
Wrist ext	40 with compensation	45	50	60	65	70	NT
Radial/ ulnar deviation	NT	NT	NT	NT	NT	15/30	NT

Table 2 Strength

	May 2014 (MyoPro Classic)	Sept 2014	Nov 2014 (MyoPro Motion G)	Jan 2015	March 2015	March 2016
Strength (MMT w/o MyoPro)						
Shoulder	3-/5	3-/5	3-/5	3-/5	3-/5	4/5
Elbow	3-/5	3-/5	3-/5	3-/5	3/5 Pro/Sup 3/5	4/5
Wrist	3-/5	3-/5	3-/5	3-/5	Flex 3-/5 Ext 3/5	NT
Hand	3-/5	3-/5	3-/5	3-/5	2-/5	NT
Grip (L hand)	21 lbs	31 lbs	36 lbs	40 lbs	47 lbs	NT
Lateral pinch	NT	NT	NT	NT	11 lbs	NT

DISCUSSION

Regular and consistent use of the custom myoelectric EWHO in conjunction with traditional OT has resulted in many benefits and positive functional outcomes for the participant. The myoelectric EWHO was shown to provide both assistive device benefits as well as rehabilitative benefits. While wearing his orthosis, he is able to be more independent with daily ADLs and IADLs such as meal preparation, folding and washing clothes, accessing items in overheard cabinets, bilateral lifting tasks (e.g. laundry basket, dining chair), sweeping/mopping and stabilizing objects such as cups and plates. Once fitted with the myoelectric EWHO with grasp, the participant demonstrated significant improvement in his affected hand function in particular, again both without and without the myoelectric

EWHO donned. Consistent use of this myoelectric orthosis over time has also resulted in dramatic therapeutic improvements in the range of motion and strength and a reduction of spasticity in his paretic arm. The participant's comment that not using his myoelectric EWHO with grasp for longer than 2 days results in his arm and hand stiffening and losing function, suggests that the changes he has experienced in his arm are largely due to the integration of the myoelectric EWHO into his therapy regime (Table 3 Spasticity). Looking at the data from November 2014 onwards (in particular March 2015 – October 2015), we see improvements in gross grasp as well as lateral pinch strength and wrist ROM and blossoming ulnar and radial deviation. With this new found hand function and increased UE strength overall, the participant demonstrates competence with tasks such as opening doors and cupboards with his affected hand, as well as using a measuring tape (bilateral task), picking a phone off the hook and holding papers, all without using the myoelectric EWHO. Results from the Fugl-Meyer (Table 4 Fugl Meyer) assessment (specifically in the wrist, hand and coordination/speed categories) also support a significant training effect and remediation of upper extremity paresis. Since the participant also engaged in traditional OT, it should be noted that it is challenging to separate the progress made by just traditional therapy versus the effects of the myoelectric EWHO without grasp capabilities. It is reasonable to conclude that incorporating a myoelectric EWHO into a comprehensive treatment program offers excellent results. However, given the participant's level of hand function immediately prior to receiving the myoelectric EWHO with grasp, it does seem reasonable to conclude that the added myoelectric grasp feature contributed directly to the participant's significant distal fine and gross motor recovery.

Table 3 Spasticity

	Jan 2014	May 2014 (MyoPro Classic)	Sept 2014	Nov 2014 (MyoPro Motion G)	Jan 2015	March 2015	March 2016
Spasticity (Modified Ashworth Scale)							
Elbow Flex	1+	1	0	0	0	NT	0
Elbow Ext	1+	0	0	0	0	NT	0
Wrist Flex	1+	0	0	0	0	NT	0
Wrist Ext	1+ with 2 beats clonus	1	1	0	1 with clonus	NT	0

Table 4 Fugl Meyer

	March 2015	March 2016
Upper Extremity	31/36	31/36
Wrist	9/10	10/10
Hand	9/14	14/14
Coordination/Speed	3/6	6/6
Sensation	11/12	11/12
Passive Joint Motion	24/24	24/24
Joint Pain	24/24	24/24
Total Score	111/126	120/126

CONCLUSION

This custom myoelectric EWHO was shown to provide this veteran with an increased ability to move and use his affected arm in a variety of functional tasks, in particular bilateral tasks. The participant wears his myoelectric EWHO on and off throughout a day and reports improvements in his independence with daily functional tasks and overall quality of life. This participant has also demonstrated significant recovery in his affected upper extremity including improved active range of motion at the shoulder, elbow and hand, improved strength and a reduction in tone. This case report highlights both short term assistive and functional benefits as well as long term rehabilitative benefits of a myoelectric orthosis. These devices offer an exciting opportunity for other individuals diagnosed with chronic stroke or brain injury to make advancements towards their recovery and independence, and warrant additional research into the application of custom myoelectric EWHOs for veterans and active duty personnel.

REFERENCES

Desrosiers, J., Noreau, L., Rochetta, A., Bourbonnais, D., Bravo, G., & Bourget, A. (2006). Predictors of long-term participation after stroke. Disability and Rehabilitation, 28, 221 -230.

McLean,L. & Scott, R.N. (2004). The Early History of Myoelectric Control of Prosthetic Limbs (1945 –1970). In A. Muzumdar (Ed.), Powered Upper Limb Prostheses (pp1-2). Location: Springer-Verlag Berlin Heidelberg.

Prentke, T. (1969) A Surface Electrode Design for Myoelectric Control. Orthopedic and Prosthetic Appliance Journal, 23, 63-67

Sauter, W.F., Bush, G. (1989). Myoelectrically controlled exoskeletal mobilizer for amyotropic lateral sclerosis (ALS) patients. Prosthetics and Orthotics International, 13,145-148.

Skidmore, E., Rogers, J., Chandler, L., & Holm, M. (2006). Dynamic interactions between impairment and activity after stroke: examining the utility of decision analysis methods. Clinical Rehabilitation, 20, 523- 535..

Slack, M., Berbrayer, D. (1992). A myoelectrically controlled wrist-hand orthosis for Brachial Plexus Injury. Journal of Prosthetics and Orthotics, 4,171-175.

Waring, W., Antonelli, D. (1967). Myoelectric Control for a Quadriplegic. Orthopedic and Prosthetic Appliance Journal, 21, 255-258.