The effect of myoelectric upper-extremity orthoses on rehabilitation outcomes in hemiplegic patients

K. A. Neely, MSOP; Geauga Rehabilitation Engineering O&P; neelykal@gmail.com

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Clinical Question: Does the use of a myoelectric elbow or elbow-wrist-hand orthosis increase the functional capabilities of the affected upper extremity in chronic hemiplegic patients?

Background: Chronic upper-extremity (UE) neuromuscular impairment affects millions of people in the United States. Flaccid and spastic paralysis of the UE can result from stroke, traumatic brain injury (TBI), brachial plexus injuries (BPI), as well as many other etiologies, and this condition leaves patients unable to perform volitional elbow, wrist, and/or hand motion.[1-10] Impairments are chronic if they persist for longer than 6 months. The ability to complete activities of daily living and functional tasks decreases without control or range of motion of the elbow, wrist, and hand in the affected arm. Deficits in the upper extremities greatly impact and reduce quality of life and level of independence.[1] Motor learning-based (MLB) therapy with repetitive activity-based intervention has been shown to improve functional outcomes, but with reduced function in the affected extremity, participation in these therapies is limited.[2-4]

Myoelectric upper-extremity orthoses (MUEO), such as the MyoPro (Myomo, Boston, MA), are sometimes used in MLB therapy. These orthoses are custom made for each patient and use EMG signals to recognize volitional muscle contraction. Built-in motors help complete motion at the hand or elbow as indicated from the sensed contraction. A MUEO is intended to help train the user to activate and relax muscles corresponding to desired motion and strengthen the otherwise unused arm, increasing functional use of the paretic extremity and participation in MLB therapies. Small sample studies have been conducted regarding the effect of a MUEO on rehabilitation outcomes in a variety of populations with upper-extremity impairment. An analysis of available literature was conducted to evaluate if evidence exists to indicate a MUEO positively impacts rehabilitation and functional use of a paretic UE.

Search Strategy:
Databases Searched: O&P IQ, PubMed, CINAHL
Search Terms: "Myoelectric" AND ("orthosis" OR "orthotic" OR "orthoses") AND ("upper extremity" OR "upper limb" OR "arm" OR "hand") NOT ("prosthetic" OR "prosthesis" OR "protheses")
Inclusion/Exclusion Criteria: 2010-present, English, Peer-Reviewed Journal paper

Synthesis of Results: A total of six articles were included (Table 1). One study evaluated patients with BPI,[8] five evaluated stroke patients,[2,4-6,9] and one included TBI patients.[4] All patient populations presented with chronic weakness and diminished function of the UE. Sample size for the included studies ranged from n=9[6] to n=34.[5] Studies varied in duration of use with the MUEO from one day[2,9] to multiple months-long phases of therapy.[4-6,8] Almost all studies compared outcomes using the device to a baseline taken prior to use of the device.

Outcomes included Fugl-Meyer (FM) assessment scores,[2,4-6] Modified Ashworth Scale (MAS) results,[4,6] Box and Blocks (BB) test scores,[2] measurements of range of motion,[4,8-9] and muscle strength,[8] DASH scores,[8] Chedoke scores,[4] and subjective patient reports.[4] Key findings from these studies consistently show improved functional outcomes with increased FM scores, increased ROM, and/or increased ability to complete tasks or decreased perceived disability (DASH, Chedoke, BB, functional tasks).[2,4-6,8-9] Findings also suggest an influence of patient compliance on sustained improvement once released from therapy or in-clinic phases.[4,6]

Potential limitations of the evidence presented include: (1) small sample size studies, including only one randomized controlled trial; (2) a lack of comparison to a traditional therapy control; (3) data analyzed containing multiple iterations or versions of the MUEO device; (4) the outcome measures used may not be valid representations of functional mobility.

Clinical Message: While individual study sample size was small, results remained consistent across multiple studies. Results in short-term studies indicate that a MUEO supports the affected extremity and increases functional capabilities while wearing the device. Available literature from longer-term studies indicates that in addition to supporting the weakened extremity, motor-learning-based therapy completed using a MUEO effectively increases functional capabilities in the affected upper extremity for chronic upper extremity impairment caused by stroke, TBI, or BPI beyond that seen in traditional therapy alone. The available literature shows that discontinued use of therapeutic intervention with the device results in loss of the marked increased functional capabilities.

References:

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	Pulos et al., 2021[8]	Peters et al., 2017[2]	Page et al., 2020[5]	McCabe et al., 2019[6]	Pundik et al., 2022[4]	Hoppe-Ludwig et al., 2019[9]
Population	Adult traumatic BPI patients from a specialized clinic who had failed to achieve antigravity elbow flexion following injury or reconstruction.	Chronic, stable, moderately impaired stroke survivors with UE hemiparesis.	Subjects with chronic, moderate, stable, post-stroke upper extremity hemiparesis.	Stroke patients > 6 months post stroke who underwent treatment at an outpatient OT department and had reached a plateau in functional performance following traditional OT.	Individuals with chronic moderate/severe arm weakness due to stroke (n=7) or TBI (n=6).	Individuals with stroke.
Study Design	Retrospective chart review from a single institution.	Observational cohort study.	Randomized, controlled, single-blinded design.	Retrospective analysis of data collected longitudinally.	Single group interventional study.	Single-session study.
N	19	18	34	9	13	18
Intervention	Orthotist-fit MyoPro used in therapy with a Certified Hand Therapist.	MyoPro Motion-G device.	MyoPro used 1 hour/day for 3 days/week over 8 weeks.	MyoPro used with group therapy 1-2 days/week and recommended at-home use.	MyoPro used with therapy 2 days/week for 9 weeks followed by an at-home prescribed exercise program for 9 weeks.	MyoPro fit and used for one session.
Comparison	Used paired t-test to compare before and after MUEO therapy.	UE impairment and function before wearing a MUEO and after.	MUEO and repetitive, task-specific practice; task specific practice only; MUEO only.	Plateau/pre-intervention levels versus scores over time.	No control group; outcomes collected baseline, weeks 3, 5, 7, 9, 12, 15, 18.	Performative, compared to baseline without device.

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Methodology	Therapy notes were reviewed to collect data on the three outcomes before and after MUEO therapy, as well as demographic information.	During one visit, participants were fit with the MUEO; during a second visit, subjects were administered the tests in the same order first without wearing the MUEO, and after completion were administered the tests after donning the MUEO. Same day, same rater for all subjects and all tests.	Participants randomized to one of the 3 treatment groups with treatment administered for 1 hour/day on 3 days/week over 8 weeks.	Fit with a MUEO after plateau and put into group therapy (supervised phase) and then a home exercise program (unsupervised phase).	In-clinic phase included 18 sessions (2 days/week for 9 weeks) plus a home exercise program, while home phase included practice of the home exercise program.	Single-session study in which participants were screened and tested for baseline functionality and after an acclimation period tested usability and functionality of the device.
Outcomes	BMRC-muscle strength, DASH-upper-extremity function, VAS-pain	FM, functional tasks, BB test	FM, Arm Motor Activity Test (AMAT)	FM, MAS	FM, MAS, ROM, Chedoke, O&P User's survey	Ability to activate the device, hold weights, ROM
Study Limitations	Did not control for device version.	Study used a not validated means of testing functional tasks.	Regimented therapy tests in the study versus self-selected relevant tasks in the clinic.	Therapy session attendance varied (inconsistent timing over which testing was completed); missing or incomplete data sets, especially in the unsupervised phase; periods of time in the unsupervised phase where patients may have been without the device waiting for an updated one.	No control group. No blinding. Small sample size.	Did not include patient reports. Used both custom and adjustable versions of the device. Impairment outside of MAS was not determined prior to the study. No baseline for holding weights. Small sample size.

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Key Findings	Participants demonstrated a statistically significant improvement in strength following MUEO therapy. Median time to device in patients that showed improvement was 18 months compared to 30 in patients who did not achieve improvement. At final follow-up, the DASH score showed a significant improvement of 11 points. There was a positive correlation between improvement in muscle grade and improvement in DASH.	There was a statistically significant difference in UE impairment as measured by the FM Scale($P<0.0001$, mean score increase of 8.72) when using a MUEO compared with while not wearing the MUEO. There were observed significant increases in median BB scores while wearing the MUEO versus while not wearing the MUEO ($P< 0.001$) Subjects increased ability to perform functional tasks, including significant increases in ability to grasp a utensil ($P= .024$) and bring it to their mouth ($P=0.003$) and grasp a cup ($P=0.001$).	All 3 cohorts exhibited score increases from pre-intervention scores to post-intervention FM scores of approximately +2 points, resulting in no differences in the amount of the change between groups. Average Arm Motor Activity Test (AMAT) scores between pre-intervention and post-intervention were approximately +1 for all three groups, resulting in no difference in the amount of change between groups.	For participants evaluated at about 12 weeks of working in the supervised phase, there was statistically significant change in FM of average 7.3 points ($P= 0.017$). At the conclusion of the supervised phase, a statistically significant change from initial FM was observed of 9 points ($P = 0.00053$). Seven out of nine patients demonstrated a FM change score >5 points at the end of the supervised phase. 4 patients followed into the unsupervised phase showed declines in FM as compared to post-supervised phase but were still improved compared to initial score.	Statistically significant changes from baseline were observed by week 3 of in-clinic phase, continued to improve after week 3 through the end of clinic phase, and were maintained during the home phase. Baseline FM nor injury type were associated. Difference in MAS at all time points compared to baseline was significant. MAS improved by week 3 and remained reduced through the end of the home phase. Higher baseline MAS scores saw greater reduction. A statistically significant improvement from baseline in the O&P User's Survey was observed by the end of the in-clinic phase and maintained at the end of the home phase.	71% of users were able to operate all three active modes during testing. Users were able to hold a range of wrist weights for a range of time. The MUEO was found to improve ROM in use. More patients were able to complete the active ROM task using the device than without it.

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Key Findings (Con't)		Subjects also showed a not statistically significant different but higher mean scores for grasping a laundry basket and turning on a light switch with the MUEO.		While no statistically significant pre to post change was observed with a group-wise comparison, improvements in elbow flexor and wrist flexor tone was seen in most patients. For 3 patients with MAS >1.5 at initial testing, there was a consistent improvement in MAS score during the supervised phase.	A statistically significant improvement from baseline in active ROM for elbow flexion was seen by week 5 and maintained through the end of the home phase. Elbow extension active ROM improved by week three and was maintained through the end of the in-clinic phase. Higher active ROM baselines saw less improvement. Statistically significant improvement from baseline was noted for CAHAI by week 3, and scores continued to improve through the end of the home phase. Compared with week 5 scores, statistically significant improvements were observed at the end of home phase, average change of 8.8 points.	