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Augmenting Hand and Arm Function for Persons with Hemiparesis

Brooke Stein
brstein@chapman.edu

Susan Duff
Chapman University, duff@chapman.edu

Alison McKenzie
Chapman University, amckenzi@chapman.edu

Bailey Advincula
Chapman University, badvincula@chapman.edu

Isaac An
Chapman University, ian@chapman.edu

See next page for additional authors

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Abstract

Background. Hand and arm dysfunction due to neural disorders significantly influences quality of life. Activity-based training has been found to improve function. These improvements could be augmented with transcutaneous spinal cord stimulation (tSCS) due to the modulatory effect it has on spinal and supraspinal networks. Objective. The primary aim is to determine if a 4-week training program will improve hand and arm function. The secondary aim is to determine if the addition of tSCS to a second 4-week training session will further improve function. Design. This is a pre-posttest, controlled trial for persons 10-75 years of age, >6 months post stroke or with unilateral cerebral palsy.Methods. Participants will engage in two 4-week training periods, 3x/week for 2 hours/day. The 1st period will include unimanual and bimanual training alone. The 2nd period will be augmented with low frequency tSCS to the C5-T1 spinal region. Stimulation intensity will be based on individual muscle activation during 3 tasks: 1) grip dynamometry; 2) grip-lift; and 3) target pointing. Outcome measures taken before, midway, and after training are: Canadian Occupational Performance Measure (COPM), dexterity, daylong arm use, grip/pinch strength, sensibility, questionnaires, bilateral hand/arm surface electromyography, and Upper Extremity Fugl-Meyer (UEFM). Results: Nine participants have completed the 1st 4-week training period without tSCS. Individual data reveals improvements in the COPM, Grip strength, dexterity, and the UEFM. Findings for other measures after the 1st period are mixed or in process. Conclusion: Preliminary findings from this ongoing study reveal that participants made improvements in most measures. The next phase of the study will determine if the addition of tSCS to training further augments hand and arm function.

Disciplines

Neurosciences | Physical Therapy

Authors

Brooke Stein, Susan Duff, Alison McKenzie, Bailey Advincula, Isaac An, Annie Jeon, Casey McWilliam, Will Potter, Virginia Ruano, Paulina Vokulich, Audrey Howell, and Rahul Soangra

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Stein B;[1] Duff SV;[1,2,3] McKenzie M; [1] Advincula B;[1] An I;[1] Jeon A;[1] McWilliam C;[1] Potter W;[1] Ruano V;[1]
Vokulich P;[1] Kimbel A;[1] Howell A;[1] Soangra R[1]
[1]Chapman University, Irvine, CA; [2]Rancho Research Institute, Downey, CA; [3]Cedar Sinai Medical Center

BACKGROUND

- Persons with hemiparesis due to stroke or cerebral palsy (CP) often have arm dysfunction resulting disability and a suboptimal quality of life.[1]
- Research supports the use of non-invasive transcutaneous spinal cord stimulation (tSCS) to improve grip strength & function after SCI, using non-invasive, non-commercial devices.[2-4]
- It is unknown if individually targeted prehensile training could be further enhanced if paired with tSCS applied with a commercial device. [5]

PURPOSE

- Primary Aim - Determine if a 4-week hand and arm training program would improve unimanual and bimanual function in persons with hemiparesis.
- Secondary Aim - Determine if use of tSCS in a 2nd 4-week training period would further improve function.

METHODS

Study Design: Subset of larger pre-test, post-test-controlled trial

Inclusion criteria:

1) 10-75 years old
2) ≥ 6 months with hemiparesis
3) Weakness (<4/5) ≥ 1 upper extremity muscle group
4) Upper Extremity Fugl Meyer (UEFM) of 27-42
5) UE muscle activation bilaterally verified by tSCS and surface electromyography (SEMG) with 3 tasks
6) Ability to hold objects in either hand using any pattern

Exclusion Criteria:

1) Resting heart rate (HR) <40 or >100 beats/min
2) Resting blook pressure (BP) <90/60 or >160/90 mmHg
3) Chest pain or shortness of breath at rest
4) UE Joint contractures >20º wrist/elbow or > 45º at glenohumeral joint (any plane)
5) Botox injection within 4 months (either arm)
6) Pregnancy
7) Implanted pacemaker/anti-spasticity pump
8) Cardiac disease
9) Fear of stimulation hindering tolerance to training

Table 1: Demographics of 8 Participants

ID	Age (yrs)	Post Injury (yrs)	Gender	Paretic Arm	EHI
STR 01	29	4.5	M	Left	100 R
STR 02	72	13.5	M	Right	(-75) L
STR 03	28	2.5	F	Left	100 R
STR 04	62	6.5	F	Left	100 R
STR 05	28	4.0	F	Left	100 R
STR 06	25	2.0	F	Right	62.5 R
STR 07	31	4.0	F	Left	62.5 R
STR 09	19	17.0	M	Left	100 R

EHI = Edinburgh Handedness Inventory; ID = Identification; kg = kilograms; yrs = years

OUTCOME MEASURES

- **Canadian Occupational Performance Measure** (COPM): 3 meaningful tasks
- **Upper Extremity Fugl Meyer** (UEFM)
- **SEMG Muscle Activation**
  1) Grip dynamometry; 2) Grip-Lift Task (A); 3) Pointing
- **Grip / Pinch Strength**
- **Adult AHA-Stroke**[6] **(B)**
- **Dexterity** (Box & Blocks, FDT, 9-Hole Peg Test)
- **Sensibility** (2-point discrimination, Monofilaments)


A


B

TIMEPOINTS
V1 = Baseline
V2 = After 1st Period
V3 = After 2nd Period

INTERVENTION

Training program

- Run in pairs; 2 hours, 3x/wk.
- Two 4-week training periods:
  1) *Prehensile training alone (C,D)*
  2) *Training with tSCS*
- Each session includes:
  1) *Aerobic warm-up*
  2) *Unimanual training of paretic limb*
  3) *Bimanual training (E) symmetrical/asymmetrical tasks*


C


D


E

Second training period with tSCS using biphasic waveform at low frequency (20-30Hz), pulse width 100 us, amplitude 6-30mA using ***Chattanooga Continuum*** *(Dallas, TX)*
Cathode – C-Spine, Anode – Iliac crests (F,G)


F


G

PRELIMINARY RESULTS

COPM #1 Task

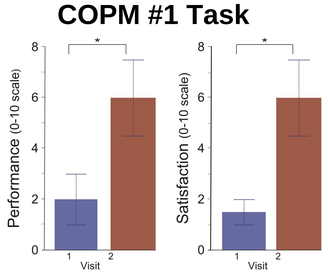

Table 2: COPM All Tasks

ID	Most Important Task
STR 01	Basketball
STR 02	Write with R hand
STR 03	Doing hair
STR 04	Carry bag L hand/arm
STR 05	Hold dog leash L hand
STR 06	Typing
STR 07	Doing hair
STR 09	Opening containers

ID	Visit 1		Visit 2		Visit 3	
	P	S	P	S	P	S
STR-03	1	1	6	6	8	10
STR-07	2	2	6	7	2	2

Fig. 1. COPM. Median +MAD and Table with all tasks – 2 participants after 2nd period

Upper Extremity Fugl Meyer

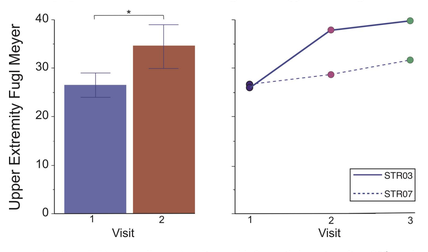

Fig. 2. UEFM. Median +MAD; and) 2 participants after 2nd period

FDS Activation – Grip

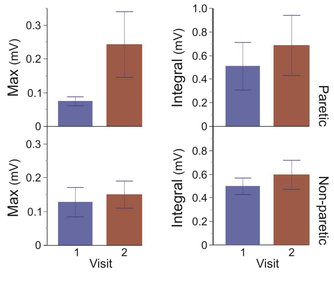

Fig. 3. FDS Max & Integral - 2 visits before & after 1st training period

SEMG Muscle Activation – Grip

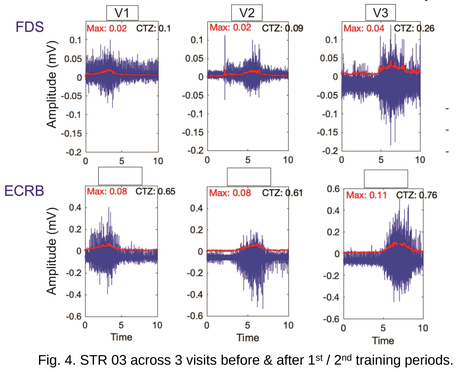

Fig. 4. STR 03 across 3 visits before & after 1st / 2nd training periods.

ECRB Activation – Grip

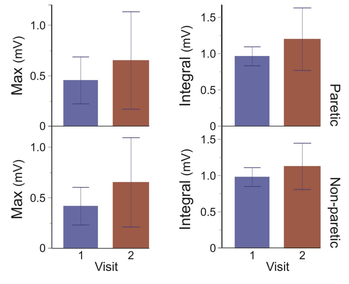

Fig. 5. ECRB Max & Integral - 2 visits before & after 1st training period

Grip Strength

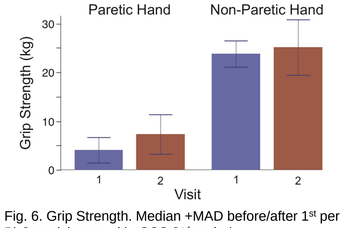

Fig. 6. Grip Strength. Median +MAD before/after 1st period; B) 2 participants with tSCS 2nd period

Table 3: Box & Blocks

ID	V1	V2	V3
STR 01	6	4	-
STR 02	3	6	-
STR 03	1	3	3
STR 04	0	0	-
STR 05	43	43	-
STR 06	41	43	-
STR 07	0	0	0
STR 09	8	9	-

***Findings TBD:** Daylong arm use, Grip-Lift task performance

Ad-AHA Stroke

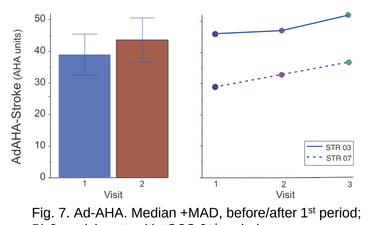

Fig. 7. Ad-AHA. Median +MAD, before/after 1st period; B) 2 participants with tSCS 2nd period

PRELIMINARY DISCUSSION

- A 4-week, intense, prehensile training program:
  - Significantly increased scores on COPM & UEFM (8)
  - Trend noted toward improvement in grip strength (7/8); Ad-AHA-Stroke (8/8); and sensibility [2-pt] (5/8)
  - 50% change in FDS/ECRB activation & dexterity
  - Findings for other outcome measures TBD
- An additional 4-week period with tSCS for n=2:
  - Improved UEFM scores, grip strength, FDS/ECRB activation, and AdAHA-Stroke scores
- We will complete prehensile training augmented with tSCS in a 2nd 4-week period with remaining 6 participants
- Future work will examine efficacy of prehensile training vs. training augmented with tSCS in a clinical setting.

Limitations

- Not all participants completed 2nd training period
- Daylong arm use & grip-lift performance TBD

CLINICAL RELEVANCE

- Preliminary results suggest that an intense, targeted, prehensile training program can improve hand and arm function.
- If outcomes from prehensile training can be further enhanced with tSCS, clinicians would have a non-invasive, commercially-available, treatment tool to use to foster hand/arm function.
- Intense, targeted prehensile training programs are limited, thus implementation of specific program ideas, into the clinic may be essential.

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