FOCAL MUSCLE VIBRATION FOR POST-STROKE REHABILITATION: A SYSTEMATIC REVIEW OF PROTOCOLS AND OUTCOMES

Sarah Bulloch, OTS-2[1], Hongwu Wang, PhD.[1], Cyndy Robinson, OTD[1]
Department of Rehabilitation Sciences[1] College of Allied Health, University of Oklahoma Health Sciences Center

BACKGROUND

Stroke is currently the leading cause of disability in the United States. After a stroke, 16% of individuals will live in a long-term care facility, 20% will require an assistive walking device, and 71% will be vocationally impaired. This happens because of the complexity of a stroke leading to complexity in the rehabilitation process. There is very little standardization of rehabilitation, and therefore clinicians and researchers are always working to better understand interventions that will best serve their patients and help them reach the greatest level of independence.

One intervention that has become increasingly studied in the last 10 years, is focal muscle vibration (FMV). The use of vibration as a therapeutic intervention dates back to the 1800s when vibration was used to relieve pain of patients with Parkinson's. Since then, it has been used as an intervention for a variety of neurological diagnoses, but it's mechanisms and protocol are not highly understood. Understanding the experimental protocols and establishing which outcome measures are commonly used in FMV studies in stroke rehabilitation may help improve consensus among researchers and clinicians.

PURPOSE

The purpose of this study is to examine the experimental protocols and identify the commonly used outcome measures in FMV based intervention studies after stroke.

METHODS

PubMed, Ovid Medline, CINHAL, Science Citation Index, and Cochrane databases were searched for FMV based intervention studies in stroke according to PRISMA guidelines. Key words for the search included stroke, post-stroke, stroke rehabilitation, focal muscle vibration, local muscle vibration, localized vibration, and local mechanical vibration *(see table 1)*. Studies were included from the last ten years, were written in English, treated patients who have had a stroke, and used focal muscle vibration as an intervention. Studies were excluded if they did not use focal vibration as the main intervention, treated multiple diagnoses, did not have at least one motor outcome, or did not report parameters for the application of vibration. Two review authors independently selected trials for inclusion, assessed trial quality and extracted data. Disagreement was resolved by discussion or, if necessary, referred to a third review author.

Table 1: Search Strategy

OVID:	96,305
CINHAL:	101,139
Cochrane:	696
PubMed:	315,898
SCI:	303,591
Total:	**817,629**

Articles for review of titles and abstracts
n= 57

Articles for full-text review
n= 26

Articles included
n= 15

RESULTS

<u>Overview</u>

26 studies met all inclusion criteria, 11 were excluded. Of the 15 included, 3 studies looked at the effects of focal vibration on the lower extremity, and 12 looked at the effects of focal vibration on the upper extremity. Table 2 gives a brief overview of the search results (*page 4)*.

Protocol

Protocol for application of focal vibration varied widely (see table 3). Frequency ranged from 60-300Hz. Amplitude was reported as “low amplitude” in 5 studies. 9 studies reported the amplitude numerically, with a range of .4mm-2mm. 1 study reported the amplitude as 10m, which cannot be converted for comparison. Duration of application varied from 5 minutes to 60 minutes.

Table 3: Study Parameters

Study #	Freq. (hz)	Amp (mm)	Duration (minutes)	# of sessions
1	60	low*	5	1
2	70	low*	30	1
3	100	0.2-0.5	10	9
4	100	low*	10	9
5	91	1.0	5	1
6	100	2.0	30	10
7	120	0.01	30	10
8	91	1.0	30	12
9	80	low*	60	40
10	100	low*	10	12
11	300	2.0	30	12
12	70	10m*	30	6
13	120	low*	30	48
14	90	.015	30	30
15	90	0.4	0.58	nr

*= did not report amplitude in mm

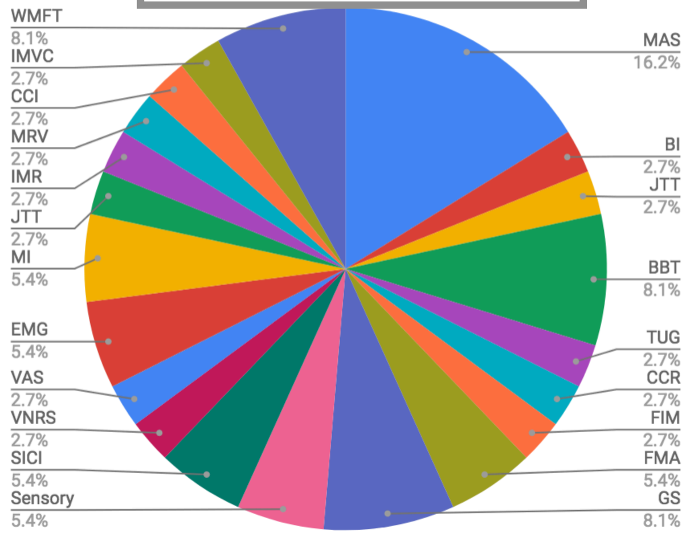
Outcomes

For outcome measures, there were 21 different outcome measures used across the 15 studies. The most commonly used outcome measure is the Modified Ashworth Scale, which was used in 7 studies. Table 4 (at right) shows all outcome measures and how commonly they were used across studies.

CONCLUSION

In conclusion, evidence does not currently support the use of focal muscle vibration as a post-stroke intervention because of the inconsistency in congruency amongst protocol, outcome measures, and results. Protocol for amplitude, frequency and duration were highly varied with no correlation to outcomes. The use of outcome measures was also highly varied, with there being over 20 outcome measures used across the 15 studies analyzed. These findings illustrated the need for more research to understand the mechanisms of FMV, and impact of different parameters on outcome measures.

Table 4: Outcome Measures



KEY FOR CHARTS

BBT=box and block test; BW%= body weight shift percent; CCI=co-contraction index; EG= experimental group; EG1=experimental group 1; EG2=experimental group 2; EG3= experimental group 3; EMG= electromyography; FIM= Functional Independence Measure; FMA=Fugl-Meyer Assessment; FMA-UE=Fugl-Meyer Assessment Upper Extremity; FMV=focal muscle vibration; GS=grip strength; HGST=hand grip strength test; HMR=H_{max}/M_{max} ratio; JTT=Jebsen Taylor Hand function Test; MAS=Modified Ashworth Scale; MI=motricity index; MR=modulation ration; MVC=maximal voluntary isometric contraction; NR= not reported; RMP= progressive modular rebalancing; SICI= short-interval intracortical inhibition; SCI= Science Citation Index; TMS=transcranial magnetic stimulation; VAS= visual analog scale; VNRS=verbal number rating scale; WMFT=Wolf Motor Function Test

REFERENCES

(15) Bonan, J. Butet, S. Jamal, K. Yelnik, A., Ponche, S. T., Leplaideur, S. (2017). Difference between individuals with left and right hemiparesis in the effect of gluteus medius

vibration on body weight shifting. *Neurophysiologie Clinique* (47).

(9) Calabro, R. S., Naro, A. Russo, M., Milardi, D., Leo, A., Filoni, S., Trinchera, A., Bramanti, P. (2017). Is two better than one? Muscle vibration plus robotic rehabilitation to improve upper limb spasticity and function: a pilot randomized controlled trial. *PLOS one* (12)10.

(4) Caliandro, P., Celletti, C., Padua, L., Minciotti, H., Russo, G., Granata, G., Torre, G. L., Granieri, E., Camerota, F. (2012). Focal muscle vibration in the treatment of upper limb spasticity: a pilot randomized controlled trial in patients with chronic stroke. *Archives of Physical Medicine and Rehabilitation (93).*

(6) Casale, R., Damiani, C., Maestri, R., Fundaro, C., Chimento, P., Foti, C. (2014). Localized 100 hz vibration improves function and reduces upper limb spasticity: a double-blind controlled study. *European Journal of Physical and Rehabilitation Medicine* (50)5.

(10) Celletti, C., Sinibaldi, E., Perelli, F., Monari, G., Camerota, F. (2017). Focal muscle vibration and progressive modular rebalancing with neurokinetic facilitations in post-stroke recovery of the upper limb. *La Clinica Therapeutica* 168(1).

(8) Choi, W. H. (2017). Effects of repeated vibratory stimulation of wrist and elbow flexors on hand dexterity, strength, and sensory function in patients with chronic stroke: a pilot study. *The Journal of Physical Therapy Science (29).*

(11) Constantino, C., Galuppo, L., Romiti, D. (2016). Short-term effect of local muscle vibration treatment versus sham therapy on upper limb in chronic post-stroke patients: a randomized controlled trial. *European Journal of Physical and Rehabilitation Medicine.*

(2) Conrad, M. O., Scheidt, R. A., Schmit, B. D. (2011). *Neurorehabilitation and Neural Repair 25 (1).*

Gillen, G. (2016). *Stroke rehabilitation: A function-based approach*. St. Louis, MO: Elsevier.

(12) Jung, S. M., (2017). The effects of vibratory stimulation employed to forearm and arm flexor muscles on upper limb function in patients with chronic stroke. *The Journal of Physical Therapy Science (29).*

(14) Lee, S. W., Cho, K. H., Lee, W. H. (2013). Effects of a local vibration stimulus training programme on postural sway and gait in chronic stroke patients: a randomized controlled trial. *Clinical Rehabilitation* 27 (10).

(1) Liepert, J., Binder, C. (2010). Vibration-induced effects in stroke patients with spastic hemiparesis-a pilot study. *Restorative Neurology and Neuroscience, 28.*

(3) Marconi, B., Filippi, G. M., Koch, G., Giacobbe, V., Pecchioli, C., Versace, V., Camerota, F., Saraceni, V. M., Caltagirone, C. (2011). Long-term effects on cortical excitability and motor recovery induced by repeated muscle vibration in chronic stroke patients. *Neurorehabilitation and Neural Repair (25)1.*

(5) Noma, T., Matsumoto, S., Shimodozono, M., Etoh, S., Kawahira, K. (2012). Anti-spastic effects of the direct application of vibratory stimuli to the spastic muscles of hemiplegic limbs in post-stroke patients: a proof-of-principle study. *Journal of Rehabilitation Medicine*. (44).

(13) Paolini, M., Mangone, M., Scettri, P., Procaccianti, R., Cometa, A., Santilli, V. (2010). Segmental muscle vibration improves walking in chroni stroke patients with foot drop: a randomized controlled trial. *Neurorehabilitation and Neural Repail* 24(3).

(7)Paolini, M., Tavernese, E., Fini, M., Franceschini, V. S., Mangone, M. (2014). Segmental muscle vibration modifies muscle activation during reachin in chronic stroke: a pilot study.

Saggini, R., Bellomo, R. G., Cosenza, L. (2017). Vibration in neurorehabilitation: a narrative review. *Medical Research Archives* 5(11).

Table 2: Overview of Studies

Study	Particip-ants(n)	Ages (years)	Onset (months)	Outcome Measures	Intervention Strategy
1	n=10	57±13	89±117	BBT[a]	EG1: FMV EG2: TMS
2	n=10	EG:45-63	EG:>12	FMA[a],_EMG[a]	EG: FMV
3	n=30	EG:63.6±7.6	EG:39.9±28.8	MAS[a], WMFT[a], SICI[a], MI[a]	EG: FMV+PT CG: PT only
4	n=49	EG:57.42±12.79	EG:100.71±82.79	WMFT, VAS, MAS	EG: FMV CG: placebo
5	n=36	RG:27-83	EG1: 2-35 EG2:2-73 EG3: 2-39	MAS[c]	EG1: Rest EG2: Stretch EG3: FMV
6	n=30	EG: 64.7±5.4 CG: 65.1±5.8	no reported	MAS[a], task, time,[a], traject	EG: FMV+PT CG: shamFMV+PT
7	n=22	EG:60.3±15.3 CG:60.7±13.2	EG:15.5±14.9 CG:13.0±5.0	CCI[a,b], MR[a], MVC[a]	EG: exercises+FMV CG: Exercise
8	n=10	EG:62.0±9.0 CG:59±10.1	EG:11.0±4.3 CG: 9.2±1.9	BBT[a,b], GS, Sensory	EG: FMV only CG: PT only
9	n=20	EG: 66±5 CG: 67±4	EG:5±2 CG:6±2	MAS[a],_HMR[a] SICI[a]	EG: Armeo-Power +FMV CG: Armeo-Power
10	n=nr	EG1: 31-69 EG2: 30-57 EG3: 2-7	EG1: 2-33 EG2: 2-4 EG3: 2-7	WMFT[a,b] MAS[a,b,c] MI[a,b], VAS[a,b]	EG1: FMV+RMP EG2: FMV+physiotherapy EG3: physiotherapy
11	n=32	EG:62.59±15.50 CG:60.47±16.09	EGL 2-33	HGST[a], MAS FIM[a], VNRS[a] quickDASH[a] FMA-UE[a], JTT[a]	EG: FMV CG: sham FMV
12	n=10	EG:62.6±8.6	EG:21.6±18	BBT[a], GS[a] Sensory	EG:FMV
13	n=44	EG:60.3±15.3 CG:60.7±13.2	EG:15.5±14.9 CG:13.0±5.0	Toe-off(%)[a] Cadence Step Length Stride Length[a] Step Width Swing Velocity Gait Speed[a]	EG: FMV+PT CG: PT only
14	n=32	EG:53.31±8.37 CG:55.73±8.27	EG:56.94±25.73 CG:49.93±29.97	Postural sway Cadence[a] Gait Speed[a] P-step length[a] P single limb support[a]	EG: FMV + exercise CG: exercise
15	n=80	EG: 54.7±10.6 CG:54.7±10.5	EG:2.0±1.3 CG: nr	BW%[a]	EG: FMV (stroke) CG: FMV (healthy)

[a]statistically significant change first group listed
[b]statistically significant change in second group listed
[c]statistically significant change in third group listed