How to Cite:
Mohamed, A. M., Salem, N. A., Massoud, M. K., & Elshreif, A. A. (2022). Effect of somatosensory stimulation on hand functions in post stroke hemiparetic patients. *International Journal of Health Sciences*, *6*(S3), 6698–6706. https://doi.org/10.53730/ijhs.v6nS3.7602

Effect of somatosensory stimulation on hand functions in post stroke hemiparetic patients

Asmaa Mahmoud Mohamed
Department of Physical Therapy El Mataria Teaching Hospital, Cairo, Egypt

Nahed Ahmed Salem
Department of Physical Therapy for Neurology, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

Magdy Khalaf Massoud
EL Mataria Teaching Hospital, GOTHI, Cairo

Abdelaziz Abdelaziz Elshreif
Department of Physical Therapy for Neurology, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

***Abstract*---**Somatosensory cues provide with the first chance to create a precise movement pattern and execute proper motor control. Somatosensory impairment can exacerbate hemiparesis, either directly because of a stroke or indirectly through the loss of the ability to interact with the environment. This study aims to investigate the effect of somatosensory stimulation on hand functions, dexterity, and handgrip strength in post stroke hemi paretic patients. This study is a randomized control trial research using two group's pre-posttest design. Thirty hemi paretic stroke patients aged between 50 to 67years were randomly assigned into two equal group ((A) study and (B) control). Group A (15 patients) received a selected physical therapy program in addition to somatosensory training While group B (15 patients) received a selected physical therapy program only. All patients undergone evaluation of handgrip strength(HGS) using handheld dynamometer, hand dexterity using box block test (BBT) and hand functional activities using Jepsen–Taylor hand function test (JTHFT). Unpaired t- test was conducted for comparison of the mean age between groups and comparison of handgrip strength, box and block test score and JTHFT between groups. Chi-squared test was conducted for comparison of sex distribution between groups. Paired t test was conducted for comparison between pre, post treatment handgrip strength, box and block test score and JTHFT in each group. After therapy, the study group had a statistically significant higher mean values of HGS, BBT scores, and a lower mean value of JTHFT scores than the control group. Handgrip strength, hand dexterity and hand

Manuscript submitted: 27 March 2022, Manuscript revised: 18 April 2022, Accepted for publication: 9 May 2022

functional activities in both groups were improved post treatment compared with that pretreatment. Somatosensory stimulation could improve handgrip strength, hand dexterity and hand functional activities in post stroke hemiparetic patients.

***Keywords*---**chronic stroke, somatosensory stimulation, hand dexterity, hand grip strength.

Introduction

According to the World Health Organization (WHO), cerebrovascular accidents (stroke) are the second largest cause of mortality and the third leading cause of disability worldwide. A stroke's effects are not limited to motor dysfunction. Sensory deficits can also produce functional limitations (Quaegebeur et al., 2016). Post-stroke hemiparetic patients have sensory and motor deficiencies in their upper limbs, and the affected upper limb's functional recovery is often poor (Frenkel- Toledo et al., 2019). The effects of hand function deficits following a stroke are complex because numerous domains may be affected so understanding the requirements of stroke patients requires knowledge of the prevalence of hand function deficits and their influence on many aspects of daily living in the chronic phase following a stroke (Mane et al., 2020).

The way we process and engage with the world and our surroundings is through sensation. It enables us to identify and discriminate objects and textures, as well as to know where our bodies are in space (proprioception) and to accurately sense and discriminate pain, temperature, pressure, and vibration sensations, (Carey et al., 2018). The detection, discrimination, and recognition of body sensations are all important aspects of somatosensory function, which guides our interactions with the environment around us (Carey et al., 2016). Somatosensation is vital for goal-directed activity as well as perception. In addition, it helps with dexterous hand movement (Dijkerman and De Haan, 2007). Up to 85% of people who have had a stroke have sensory deficits in their upper limbs, which are characterized by a loss of touch, proprioception, and warmth and pain sensation. Sensory abnormalities are linked to the severity of a stroke reduced motor function and are a predictor of treatment results. Sensory impairment can lengthen a hospital stay and make it difficult for a person to use the upper limb (UL) in normal life (Connell et al., 2008).

Somatosensory stimulation has been presented as a potential therapeutic strategy for improving the ability to do hand tasks and so strengthening the training effects of motor function following a stroke (Hatem et al., 2016). Sensory input is important for motor retraining and sensory system dysfunction can have an impact on motor skills. As a result, in post-stroke therapy, sensory input should be emphasized (Chen et al., 2018). Light touch is one of the basic sensations and a requirement for directing movement because it delivers a portion of essential sensory data (Hejazi et al., 2020). Touch, pressure, temperature, and vibration are all examples of somatosensory stimulation that can promote or decrease muscle tone and as a result, motor regulation during functional movements. In order to conduct functional movements efficiently, sensory perception in the hands is critical, and it is critical for the learning process (Sima et al., 2015).

Methods

This study is randomized control trial research using two-groups (study and control) pre- posttest design. In this study, the researcher evaluates the two groups before and after conducting the intervention. This study was conducted in Cairo, Egypt, at the Physical Therapy Outpatient Clinic, EL Materia Teaching Hospital. The study was conducted from the beginning of March 2021 to the end of January 2022. The population of this study was all 30 patients (seven females and twenty three males) with chronic stroke (ischemic or hemorrhagic) in the distribution of middle cerebral artery, selected from El Materia Teaching Hospital. The sampling technique uses randomly division into two equal groups (A &B). No droppingout of subjects from the study was reported after the randomization. The research assessment instruments used are handheld dynamometer for handgrip strength assessment, Box Block Test (BBT) for hand dexterity evaluation and Jepsen– Taylor hand function test (JTHFT) for hand functional activities assessment.

The research treatment instruments used are a vibrator, soft brush and sand paper for application of vibration, light and rough touch respectively for somatosensory stimulation. We also used a selected physical therapy program including strengthening exercises for wrist extensors and all weak hand muscles, stretching exercises for tensed muscles, reach and grasp, buttoning and unbuttoning, combing hair, pouring water from a jug into a glass, picking up an object on a table , eating with a spoon food of different consistency ,opening and closing shoes laces and opening door with a key. Group (A) received somatosensory stimulation (applied on patient's volar aspect of the hand and forearm till elbow joint from distal to proximal) and selected physical therapy program while group(B) received selected physical therapy program only. Both groups received an hour session, three sessions aweek for four weeks.

Results

Thirty hemiparetic stroke patients taken part in this study. Table (1) presents the characteristics of subjects in groups (A) and (B). Between groups, there was no marked variation in age or gender variance ($p > 0.05$). G*POWER statistical programming was used to estimate test size prior to the study (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) [F tests- MANOVA: Special effects and interaction, =0.05, =0.20, and Cohen effect size=0.25] demonstrated that N=30 was the proper sample size for this investigation. Figure (1)

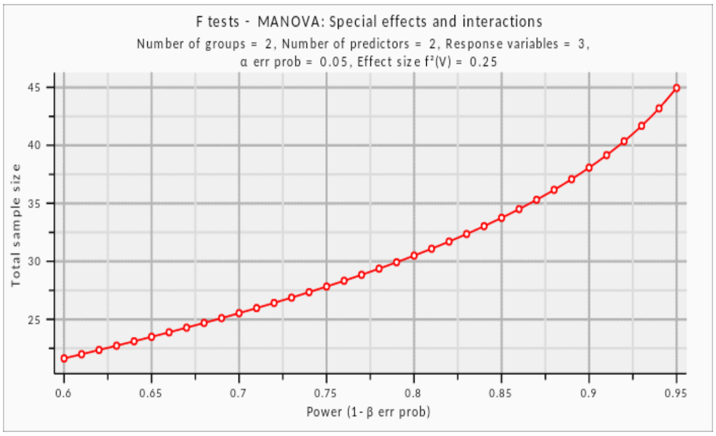

Figure 1. Power analysis for sample size

The age of patients in groups was compared using unpaired t-test. The sex distribution between groups was compared using the Chi-squared test. The Shapiro-Wilk test was used to ensure that the data was distributed normally. To ensure that the groups were homogeneous, Levene's test for homogeneity of variances was used. Unpaired t-test was conducted for comparison of hand grip strength measured by hand dynamometer, hand dexterity evaluated by box and block test scores and hand functional activities evaluated by JTHFT between groups. All statistical tests were performed with a significance threshold of 0.05. The statistical programme for social studies (SPSS) version 25 for Windows was used for all statistical analysis (IBM SPSS, Chicago, IL, USA).

Table 1
Participants' fundamental features

	Group (A)	Group(B)	Statistics	p-value
Age (years), mean ± SD	56.93 ± 6.78	55.73 ± 7.29	t- value = 0.46	0.64
Sex, N (%)				
Females	3 (20%)	4 (27%)		
Males	12 (80%)	11 (73%)	χ^2= 0.18	1

SD, standard deviation; x^2 stands for Chi squared value p-value, level of significance

Effect of somatosensory stimulation on handgrip strength evaluated by handheld dynamometer, hand dexterity evaluated by the box block test score, and hand functional activities evaluated by JTHFT

- Within-group results are compared:
  In group (A) and (B), there was a marked increase in handgrip strength and box and block test scores after treatment compared to before treatment ($p > 0.001$). There was a marked decrease in JTHFT time after treatment in comparison with that before treatment in group (A) and (B) ($p > 0.001$).
  The proportion of change in hand grip strength, box and block test score and JTHFT time of group (A) was 89.16, 33.33 and 43.21% respectively

while that in group (B) was 36.83, 17.87 and 25.3% respectively as in Table (2).

- Comparison of two groups:
  Prior-treatment, there was no marked difference between groups ($p > 0.05$). A substantial increase in handgrip strength and box block test score was observed between groups after treatment ($p < 0.01$) and a significant decrease in the JTHFT ($p < 0.05$) of group (A) compared with that of group (B) table (2).

Table 2
Mean handgrip strength, box and block test score and JTHFT before and after therapy of group (A) and (B)

	Group (A)	Group (B)			
	mean ± SD	mean ± SD	MD	t- value	p value
Hand grip strength (lb)					
Pre treatment	11.44 ± 3.57	12.11 ± 3.96	-0.67	-0.48	0.63
Post treatment	21.64 ± 4.61	16.57 ± 5.29	5.07	2.79	0.009
MD	-10.2	-4.46			
% of change	89.16	36.83			
t- value	-8.04	-4.23			
	p = 0.001	*p = 0.001*			
Box and block test score (blocks Per min)					
Pre treatment	37.8 ± 8.52	36.93 ± 7.67	0.87	0.29	0.77
Post treatment	50.4 ± 7.48	43.53 ± 6.56	6.87	2.67	0.01
MD	-12.6	-6.6			
% of change	33.33	17.87			
t- value	-12.92	-9.13			
	p = 0.001	*p = 0.001*			
JTHFT (min)					
Pre treatment	0.81 ± 0.24	0.83 ± 0.22	-0.02	-0.22	0.82
Post treatment	0.46 ± 0.18	0.62 ± 0.2	-0.16	-2.35	0.02
MD	0.35	0.21			
% of change	43.21	25.3			
t- value	7.91	7.75			
	p = 0.001	*p = 0.001*			

SD is for standard deviation; MD stands for mean difference; p-value stands for significance level.

Discussion

This study goal was to examine the impact of somatosensory stimulation including (vibration using a vibrator device ,light and rough touches using soft brush and sand paper respectively) on hand functional activities evaluated by JTHFT , handgrip strength (HGS) assessed by hand held dynamometer and hand dexterity evaluated by box block test score in post stroke hemiparetic patients.

.

It has been found that following a stroke, one in every two people experiences a loss of sensation, which affects their capacity to function independently as well as their general quality of life (Carey et al., 2018).

We included patients with ages ranged from 50-67 years old as in patients younger than 75 years of age; improved sensory function is linked to improvements in upper-limb function. In other words, for patients under the age of 75 who have had a stroke, a method that improves sensory impairment is one choice for rehabilitation targeted at improving upper-limb function (Fujita et al., 2021). Patients with shoulder girdle pain, shoulder dislocation and Patients with diabetic neuropathy were excluded from the current study. Also we avoided Patients with musculoskeletal disorders and Lower motor neuron disease that would obstruct the study's procedures and result (Sima et al., 2015).

There was a statistically marked difference between both groups as regards the mean values of HGS scores measured by hand held dynamometer, hand dexterity evaluated by BBT scores and hand functional activities evaluated by JTHFT. Study group (A) showed significant increase in hand dynamometer and BBT values and decrease in JTHFT values compared with that of control group (B) post treatment. The explanation of this finding may be attributed to a pilot RCT trial with two treatment arms was done by Carlsson et al. (2018). The goal of their study was to see if sensory re-learning combined with task-specific training was more beneficial than task-specific training alone in improving sensory functions of hand, hand dexterity evaluated by BBT, ability to do hand daily activities, perceived engagement and life satisfaction in patients with upper limb remaining sensory deficits. They came to a conclusion that when rehabilitating upper limb after a stroke, it's necessary to pay attention not just to task-specific training but also to sensory training.

These results came in agreement with Ikuno et al. (2012) who revealed that somatosensory stimulation has been presented as a feasible therapeutic strategy for improving the the capacity to do manual hand tasks and so improving the training effects on motor function following a stroke. Also Sima et al. (2015)concluded that somatosensory stimulation of the hand and forearm might help individuals with post stroke hemiparesis to improve their hand functions and mobility, with muscle vibration having a better effect than light and rough touches. In addition, Celnik et al. (2007) also concluded that in patients with chronic stroke before physical training, somatosensory stimulation of the paretic hand improved the training benefits of hand functional exercises performed in JTHFT. This impact was observed one and twenty four hours after the conclusion of training and was linked to a reduction in intracortical inhibition in the ipsilesional hemisphere's motor cortex. The use of sensory inputs (such as touch, pressure and temperature) to either aid or hinder movement recently, electric stimulation has been studied as a nonspecific sensory stimulus to improve functional hand test performance in individuals with cortical and subcortical injuries (Cuypers et al., 2010).

Also Seo et al. (2019) revealed that applying subthreshold random-frequency vibration to the wrist resulted in the release of inhibition for the Abductor Policies Brevis muscle in primary motor cortex (M1), suppression of resting alpha and beta rhythms, and enhanced grip-related event-related desynchronization activity, indicating increased sensorimotor cortical excitability/activity.

Conforto et al. (2007) also concluded that somatosensory stimulation might help patients with chronic cortico- subcortical middle cerebral artery (MCA) infarcts improve their motor skills evaluated by JTHFT. In these patients, somatosensory stimulation could be a useful adjunct to therapeutic impact therapy. Lin et al. (2014) discovered that combining mesh gloves (MG) providing tactile stimulation with mirror treatment (MT) had a significant good impact on motor recovery, particularly manual dexterity measured by BBT and grasping ability measured by Action Research Arm Test (ARAT), as well as functional transfer capacity than treatment with MT alone. Findings that had moderate to substantial effects on grip pinch, and gross motor recovery, as well as self-care were found to be non-significant.

In contradistinction, Grant et al. (2018) did not report any significant differences in hand motor deficits or activity than with traditional treatment when using somatosensory stimulation (in any form of delivery). Also, Chanubol et al. (2012) revealed that there was no evidence of a difference between Perfetti's method of Cognitive Sensory Motor Training Therapy (The therapy is based on sensory retraining at the body functions and structure level) and conventional occupational therapy in terms of the restoration of hand and arm function after stroke evaluated by ARAT, BBT, and Extended Barthel Index. In addition, Brown et al. (2018) conducted a study in chronic stroke people and concludedd that zsensorimotor integration of vibration and nerve-based afferents is strongly affected. Vibration applied to muscular belly of a focal hand muscle has a lower influence on assessments of interneuronal circuitry and corticospinal excitability within primary motor cortex (M1); however, the effect of peripheral nerve stimulation on M1 activation is unchanged in post stroke patients. Assessments of sensorimotor integration are behaviorally relevant and linked to the degree of motor function and impairment in chronic stroke patients. Their study was limited by the small sample size.

Also Choi, (2017) disagreed with the current study results and concluded that in people with chronic stroke, both vibratory stimulation and standard physical therapy are equally successful in increasing hand dexterity and both groups' grip strength improved, although the difference was not statistically significant. He also had a small sample size of ten patients five in each group (Experimental and Control). In addition, Fleming et al. (2015) revealed that when somatosensory stimulation was paired with task specific training (TST), the action research arm test (ARAT) showed short-term gains in arm functions than task specific training alone which had long-term improvements in upper limb function but their study used another assessment tools as Motor Activity Log (MAL), action research arm test (ARAT), Fugl-Meyer Assessment score (FM) and Goal Attainment Scale (GAS).

Conclusion

The current study revealed that patients with chronic stroke received somatosensory training showed significant improvement in hand grip strength, manual hand dexterity and hand functional activities.

Conflict of interest: Nil.

Source of Funding: Self-funded.

Ethical committee: All procedures were approved by Cairo University faculty of physical therapy Research Ethical Committee (NO:P.T.REC/012/003088).Before patients recruitment to the study awritten informed consent was acquired.

References

Brown, K. E., Neva, J. L., Feldman, S. J., Staines, W. R., & Boyd, L. A. (2018). Sensorimotor integration in chronic stroke: Baseline differences and response to sensory training. Restorative Neurology and Neuroscience, 36(2), 245-259. doi:10.3233/rnn-170790

Carey, L. M., Lamp, G., & Turville, M. (2016). The state-of-the-science on somatosensory function and its impact on daily life in adults and older adults, and following stroke: a scoping review. OTJR: occupation,participation and health, 36(2_suppl), 27S-41S.

Carey, L. M., Matyas, T. A., & Baum, C. (2018). Effects of somatosensory impairment on participation after stroke. The American Journal of Occupational Therapy, 72(3), 7203205100p1-7203205100p10. doi:10.5014/ajot.2018.025114.

Carlsson, H., Rosén, B., Pessah-Rasmussen, H., Björkman, A., & Brogårdh, C. (2018). SENSory re-learning ofthe UPPer limb after stroke (SENSUPP): study protocol for a pilot randomized controlled trial. Trials, 19(1), 1-8.

Celnik, P., Hummel, F., Harris-Love, M., Wolk, R., & Cohen, L. G. (2007). Somatosensory stimulation enhances the effects of training functional hand tasks in patients with chronic stroke. Archives of physical medicine and rehabilitation, 88(11), 1369-1376. doi:10.1016/j.apmr.2007.08.001

Chanubol, R., Wongphaet, P., Chavanich, N., Werner, C., Hesse, S., Bardeleben, A., & Merholz, J. (2012). A randomized controlled trial of Cognitive Sensory Motor Training Therapy on the recovery of arm function in acute stroke patients. Clinical Rehabilitation, 26(12), 1096–1104.

Chen, X., Liu, F., Yan, Z., Cheng, S., Liu, X., Li, H., & Li, Z. (2018). Therapeutic effects of sensory input training on motor function rehabilitation after stroke. Medicine, 97(48).

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. Journal of Physical Therapy Science, 29(4), 605-608.

Conforto, A. B., Cohen, L. G., Santos, R. L. D., Scaff, M., & Marie, S. K. N. (2007). Effects of somatosensory stimulation on motor function in chronic cortico-subcortical strokes. *Journal of neurology*, *254*(3), 333-339.

Connell, L. A., Lincoln, N. B., & Radford, K. A. (2008). Somatosensory impairment after stroke: frequency of different deficits and their recovery. Clinical rehabilitation, 22(8), 758-767.

Cuypers, K., Levin, O., Thijs, H., Swinnen, S. P., & Meesen, R. L. (2010). Long-term TENS treatment improves tactile sensitivity in MS patients. Neurorehabilitation and neural repair, 24(5), 420-427.

Dijkerman, H. C., & De Haan, E. H. (2007). Somatosensory processing subserving perception and action: Dissociations, interactions, and integration. Behavioral and brain sciences, 30(2), 224-230.

Fleming, M. K., Sorinola, I. O., Roberts-Lewis, S. F., Wolfe, C. D., Wellwood, I., & Newham, D. J. (2015). The effect of combined somatosensory stimulation and task-specific training on upper limb function in chronic stroke: a double-blind randomized controlled trial. Neurorehabilitation and Neural repair, 29(2), 143-152.

Frenkel-Toledo, S., Fridberg, G., Ofir, S., Bartur, G., Lowenthal-Raz, J., Granot, O., ... & Soroker, N. (2019). Lesion location impact on functional recovery of the hemiparetic upper limb. *PLoS One*, *14*(7), e0219738.

Fujita, T., Sone, T., Yamamoto, Y., Yamane, K., Tsuchiya, K., Ohira, Y., & Iokawa, K. (2021). Impact of Sensory Impairment on Improvement of Upper-limb Function in Patients under 75 Years of Age with Subacute Stroke: A Preliminary Study. Progress in Rehabilitation Medicine, 6, 20210045.

Grant, V. M., Gibson, A., & Shields, N. (2018). Somatosensory stimulation to improve hand and upper limb function after stroke—a systematic review with meta-analyses. Topics in stroke rehabilitation, 25(2), 150-160.

Hatem, S. M., Saussez, G., Della Faille, M., Prist, V., Zhang, X., Dispa, D., & Bleyenheuft, Y. (2016). Rehabilitation of motor function after stroke: a multiple systematic review focused on techniques to stimulate upper extremity recovery. *Frontiers in human neuroscience*, *10*, 442.

Hejazi-Shirmard, M., Taghizadeh, G., Azad, A., Lajevardi, L., & Rassafiani, M. (2020). Sensory retraining improves light touch threshold of the paretic hand in chronic stroke survivors: a single-subject ABdesign. Somatosensory & Motor Research, 37(2), 74-83

Ikuno, K., Kawaguchi, S., Kitabeppu, S., Kitaura, M., Tokuhisa, K., Morimoto, S., & Shomoto, K. (2012). Effects of peripheral sensory nerve stimulation plus task-oriented training on upper extremity function in patients with subacute stroke: a pilot randomized crossover trial. Clinical rehabilitation, 26(11), 999-1009.

Lin, K. C., Chen, Y. T., Huang, P. C., Wu, C. Y., Huang, W. L., Yang, H. W., ... & Lu, H. J. (2014). Effect of mirror therapy combined with somatosensory stimulation on motor recovery and daily function in stroke patients: A pilot study. Journal of the Formosan Medical Association, 113(7), 422-428.

Mane, R., Chouhan, T., & Guan, C. (2020). BCI for stroke rehabilitation: motor and beyond. Journal of Neural Engineering, 17(4), 041001.

Quaegebeur, A., Segura, I., Schmieder, R., Verdegem, D., Decimo, I., Bifari, F., & Carmeliet, P. (2016). Deletion or inhibition of the oxygen sensor PHD1 protects against ischemic stroke via reprogramming of neuronal metabolism. Cell metabolism, 23(2), 280-291.

Seo, N. J., Lakshminarayanan, K., Lauer, A. W., Ramakrishnan, V., Schmit, B. D., Hanlon, C. A., ... & Nagy, T. (2019). Use of imperceptible wrist vibration to modulate sensorimotor cortical activity. Experimental brain research, 237(3), 805-816.

Sima, S. M., Oh, D. W., & Chon, S. C. (2015). Immediate effects of somatosensory stimulation on hand function in patients with post stroke hemiparesis: a randomized cross-over trial. International Journal of Rehabilitation Research, 38(4), 306-312.