International Journal of Recent Advances in Multidisciplinary Topics
Volume 3, Issue 2, February 2022
https://www.ijramt.com | ISSN (Online): 2582-7839

Additive Effects of Brunnstrom Approach in Combination with Mechanical Vibration and Mirror Neuron Training on Upper Limb Function in Patients with Subacute Stroke- A Single Blinded Randomized Controlled Trial

Kamalika Bhattacharjee[1*], Mahesh Kumar Shou[2]
[1]*Assistant Professor, Department of Physiotherapy, Swasthya Kalyan College of Physiotherapy, Jaipur, India*
[2]*Principal Cum Senior Professor, Department of Physiotherapy, Swasthya Kalyan College of Physiotherapy, Jaipur, India*

***Abstract*: *Study Design*: A single blinded randomized controlled trial. *Background*: Stroke is one of the most unpleasant and highly destructive neurological diseases which can be described as a condition that rapidly develops localized and generalized signs of disturbed cerebral functions; approximately 85% of stroke patients face a lot of problems with their upper extremity functions. Therefore, the present clinical trial was providing evidence of improving upper limb function in patients with sub-acute stroke. *Purpose of the study*: To investigate theeffects of Brunnstrom Approach in combination with Mechanical Muscle vibration and Mirror Neuron Training on upper limb functions in patients with sub-acute stroke. *Methods*: 20 Patients was screened for the inclusion and exclusion criteria and demographic data collected from the eligible patients. Total patients was recruited with the age group between 40-70 years, and then randomly assigned into two groups: experimental Group and control group. Motricity Index and Fugl Meyer Assessment Scale were used be the outcome measures. The Experimental group was received Brunnstrom Approach (hand movement therapy), Mechanical Vibration, and Mirror Neuron Training, while control group received Mechanical Vibration and Mirror Neuron Training for 3 days per week for 4 weeks. *Results:* We found clinically significant improvement in experimental group in all outcome measures. Within group analysis improvement was significant in experimental group(p-value<0.05). But result of the study showed more clinical improvement in experimental group. *Conclusions*: This study concluded that when Brunnstorm Hand rehabilitation was added to combined approach of Mirror Neuron training along with mechanical vibration, the functioning of upper limb has been improved to a greater extent in patients with sub-acute stroke. Thus the sufferers could be more benefitted with this approach and can lead an independent life.**

***Keywords*: Brunnstrom approach; mechanical vibration; mirror neuron training; sub-acute stroke; upper limb function.**

1. Introduction

Stroke is one of the most unpleasant and highly destructive neurological disease which can be described as a condition which rapidly develops localized and generalized signs of disturbed cerebral functions which are vascular in origin and the symptoms last for more than one day [1]. It is the fourth major cause of death [2]. As per researches, approximately 85% of stroke patients face a lot of problems with their upper extremity functions because of which it becomes a significant cause of extended disability and unemployment [2, 3]. Recovery of upper limb functions depends on severity of injury, extent of motor and sensory loss and grades of spasticity [4]. Younger men are commonly affected than younger women and it is reverse in older age group [5, 2]. There are many disabilities occur in patients with including hemi paresis (50%), unable to work without assistance (30%), dependent in activities of daily living (26%), aphasia (19%), and depression (35%) and only 5% of stroke survivors regain full functional use of affected hand [5] .Mortality rate in stroke survivors depends on age, hypertension, heart disease, and diabetes[5, 6].Damage of motor function is commonly present after stroke[7].Upper limb impairment is the long term disability in stroke survivor and main focus of treatment is given to the affected arm because patient use unaffected arm during work[2, 8] . Upper extremity rehabilitation serves to be a boon for performing the activities of daily living in people with episodes of stroke and is thus important to rehabilitate as it may enhance the activities and improvement in day-to-day activities also. The body works in a close chain kinematic system and thus dysfunction in one quadrant may alter the function or over exertion on the rest of the quadrant. In post stroke rehabilitation, many technologies such as Functional Electrical Stimulation (FES) and Neuromuscular Electrical Stimulation (NMES) are effective for

*Corresponding author: kamalika0823@gmail.com

non-invasively muscle activator which restoring the motor functions of patients. Motor function recovery can also be possible with the help of task-oriented practice. Such practice has been used to reduce the inappropriate movement and facilitate normal motor function [2, 9].

Need of the study that the Brunnstrom approach, Mechanical Vibration (MV) therapy and Mirror Neuron Training (MNT)found to be effective in improving motor abilities among stroke survivors, individually but their combined effect has not been proved yet. So, it was a need to investigate whether additive effects of Brunnstrom approach in combination with MNT and MV improves the functioning of upper limb in patients with sub-acute stroke. The primary aim of the study was to investigate theto find out the additive effects of Brunnstrom Approach in combination with Mechanical Muscle vibration and Mirror Neuron Training on upper limb functions in patients with sub-acute stroke.Null hypothesis of the study is Combined effects of Brunnstrom Approach along with Mirror Neuron Training and Mechanical Vibration might not prove to be effective in improving upper limb functions in patients with sub-acute stroke

2. Design and Methods

This study was a single blinded randomized controlled trial. The study has been approved by Institutional Ethical Committee (IEC – 1532) and was followed the guidelines of Helsinki Declaration, 2013 and also performed according to the National Ethical Guidelines for the Biomedical and Health Research involving Human participants given by Indian Council of Medical Research, 2017. The study was prospectively registered under Clinical Trial Registry – CTRI\2020\04\024484with secondary Id as Universal Trial Number (UTN) U1111-1257-4680. Information about the study was providedboth orally and in writing to potential participants. All participantsgave their written consent before being included in the study.

1) Sample size

The sample size was calculated using the G*power tool. Hand Grip Strength values for studies related to patients with sub-acute stroke was considered given that this is the primary outcome measure used herein. Mean post- (18.47) and pre-intervention (14.67) values were considered and further divided according to calculate the effect size (0.71). The level of significance will be set at 0.05. To obtain a power of 80%, a sample size of n=18 in each group would be needed. Moreover, considering a 10% dropout rate, a final sample of n=20 (10 in each group) has been recruited [10].

2) Participants

Participants were adults with subacute stroke who were recruited from Neurosurgery ward and Medicine Ward of a tertiary care hospital. Inclusion and exclusion criteria are listed in Table 1.

Table 1
Participants

Inclusion Criteria	Exclusion Criteria
Age between 40-70 years	Uncooperative Patient
Both male and female	Patients with psychological problem
Stroke more than 1month and less than 6months	Others neurological disorders
Fugl Meyer assessment scores for upper extremity function between 15-40	Visual impairment
Mortricity index score of upper limbs between 20-50	Any other musculoskeletal disorders of extremity
Both Hemorrhagic and ischemic stroke	

3) Randomization and allocation concealment

Patients were stratified into two groups, according to their criteria. Block Randomization was performed. Twenty participants were allocated randomly into 5 blocks having a matrix dimension of 4×5, where every block consisted of 4 chits (2 chits per group). Patients were request to choose one chit then allocated into that group. Allocation concealment was performed by the method of sequentially numbering opaque sealed envelopes which depicted block randomization for allocation of equal number of participants within each group. The study participants were completely unaware of their allocation to some respective groups and whether there was a difference between the group interventions.

4) Interventions

Experimental Group – Experimental group receives Brunnstrom Hand Movement rehabilitation, Mechanical vibration and Mirror Neuron Training for 3 alternate days per week for 4 weeks.

Control Group – Control group receives Mechanical vibration and mirror neuron training for 3 alternate days per week for 4 weeks.

5) Brunnstrom Hand Movement Therapy

Brunnstrom movement therapy for the hand is known as Brunnstrom Hand Manipulation (BHM). BHM uses synergistic muscle linkage and reflexive movements to achieve voluntary control of hand and finger movements. This series of manipulation was described by Brunnstrom to achieve voluntary control of the hand in a refined manner. BHM specifically emphasizes movements and stability of the wrist and hand movement of affected extremity into flexion and then extension. V shaped hand support avoids stimulation of grasp region, movement of the extremity into flexion and extension, movement of extremity into extension, passive mobilization of scapula (upward rotation), pain free shoulder motion (shoulder elevation), starting position with arm supported and wrist extended, with patient actively cooperating, bilateral shoulder protraction and retraction to mobilize shoulder girdle (retraction and protraction), voluntary shoulder external rotation, waist squeezes with semi-voluntary elbow extension, bilateral rowing activities, flexor pattern with handshake grip, extensor pattern with handshake grip, flexor pattern with thumb grip, extensor pattern with thumb grip, weight bearing with extended elbow or upper limb and arm abducted. The protocol of Brunnstrom approach for upper limb has been given with 10 repetitions in 3 sets.

6) Mechanical Vibration

The subjects were made to sit on couches in long sitting position. The paretic upper limb was exposed and relaxed. The vibratory pad was placed on the muscle belly of shoulder and elbow (flexors and extensors) as per the synergy pattern of the upper limb with high frequency (100-150Hz), low amplitude (1-3mm) for 20 minutes.

7) Mirror Neuron Training

Mirror neuron system training contains the following parts including some of the daily hand action videos, such as cracking a peanut, cutting a watermelon, combing of hair, etc, using the video devices; where the patients could see their hand action videos. This kind of action observation training (AOT) was reported to activate the mirror neuron system (overlap with motor, language, and cognition neural circuits) and therefore improve motor and cognitive functions. The functional tasks planned will be simple movements. Each video will be playing for 2 min, 2 sets of training sessions with 10 repetitions.

8) Measurements

All outcome measureswereassessed at baseline and after 2ndand 4thweeks of interventions. All instruments and assessment tools used during the intervention have good validity and reliability. Here, outcome measures used for assessment were Fugl-Meyer Assessment (ICC=0.96) for wrist and hand and Motricity index for measuring grip strength (r>.74) [32, 33].

9) Fugl Meyer assessment for upper extremity

The Fugl Meyer assessment scale is an overall 226-point multi-items scale initially developed to evaluate hand functions in patient post hemiplegic stroke. The scale has five components: joint range of motion, motor function, sensory function, balance, and joint pain. Each component itself contains various different items. It has a scoring of a 3-point measures and is an ordinal scale (0 = cannot perform, 1 = performs partially, 2 = performs fully).

The motor component includes items which measure the criteria of movement, co-ordination, and reflex action exhibited by the extremity. The motor component varies within ranges of 66 points for the upper limb functions and 34 points for the lower limb functions. Similarly, there is maximum scoring of 24 points for sensory domain, 14 points for sitting and standing balance domains, 44 points for joint range of motion domains and, 44 points for joint pain criterion. The FM assessment is best administered by a trained physical therapist on a one-to-one basis with the patient. It takes approximately 30 minutes to administer [34].

10) Motricity Index

The Motricity Index has been previously used in various studies. The scale is just another scale and type of Medical Research Council scale which is designed to measure the activation of muscle groups pertaining to active movements to assess the muscular strengths. The patient while in high sitting posture are evaluated for their power and range of active movement are then rated for shoulder abduction, elbow flexion, and pinch between the thumb and index finger. Each movement is rated on a 5-point scale. The points on the scales are given weightage scores to reflect the significance of each point on the scale as a proportion of the total recovery. A total score is calculated for the three movements.Motricity Index is a more practical measure that can denotethe overall patients' limitation and is more reliable and valid tool as compared with other scales measuring the same domains. It is a simple, brief measure of general motor function that predicts the mobility outcomesin patients with post-stroke anomalies. The validity of the Motricity Index for the upper extremity is supported by the high degree of association between its components and its correlation with both grip strength and a measure of upper extremity function [30].

11) Statistical methods

Data were collected and analyzed by the primary researcher. Baseline characteristics of eligible participants were presented using descriptive statistics. The Normality test, the Shapiro-Wilk test was used to check the normal distribution of the sample size. The appropriate statistical test was used to achieve the aims of the study like Median, range and the level of significance (LOS) was kept at 0.05 with a 95% confidence interval (CI). Within the group analysis was performed using Friedman's test and between the groups analysis was done by Mann-Whitney U test. Based on data normality, descriptive statistics were expressed mean and standard deviation. Comparison between interventions was analyzed using Wilcoxon Signed Rank test. The level of significance was set at 0.05 for all analyses. Statistical analysis was performed using the IBM SPSS statistical software version [20]. Graphical presentation of the data was represented by Box and Whisker Plots. Effect size was calculated by Cohen's d method for within group by the formula: (M1-M2)/SDPre [31] where M1 was Mean of post intervention value, M2 was Mean of pre intervention values and SD was standard deviation of pre intervention values and post hoc retrospective power analysis was done by using G* power software [35].

3. Results

Table 2
Demographic characteristics of the study participants

Characteristic	Experimental group (n=10)	Control group (n=10)	p-value
Age	57.10±10.55	56.40±9.77	0.88
Male\female [n(%)]	7/3 (70/30)	5/5 (50/50)	$X^{2:}$ 0.83
Height (cm)	166.43±4.05	162.20±7.30	0.13
Weight (kg)	61.10±12.87	58.00±10.09	0.56

Abbreviations: n= number of participants; cm = centimeter; Kg = Kilogram; X2 = Chi-square test; p-value = level of significance (set at >0.05)

Interpretation - Table 2 showed that demographic characteristics of the participants are normally distributed.

Table 3
Difference between Baseline, 2nd week and 4th week treatment outcome measures in Experimental and Control Group

Outcome Measures	Measures	Experimental group Median	Control group Median	Range	p-value
FMA-UE	Baseline	33	29	17-43	0.168
	2nd Week	45	35	23-55	0.001*
	4th Week	53	40	30-64	0.001*
MI	Baseline	38	28	23-47	0.02*
	2nd Week	52	34	33-57	0.001*
	4th Week	57	43	33-66	0.001*

Abbreviations: FMA-UE; Fugl Meyer assessment scale – upper extremity, MI; Morticity Index.

Interpretation - Table 3 shows comparison of between groups interventions expressed as median and range. p-value<0.05 was considered as significant.

1) Discussion

The study involved the treatment procedures for the patients with sub-acute stroke within hospital-based settings. There have been various studies suggesting about the prevalence and co-morbidities along with severe disabilities in patients with sub-acute stroke which is independent of the condition, grading and duration of the onset of attack. Still studies have only focused on the functions and abilities of the lower extremity as it becomes evident in patients to improve balance and gait abnormalities for proper functioning of the activities of daily living.

It was seen through previous literatures that studies revolving around the lower extremities are ample to support the evidence of treatment strategies but the same strategies are effective for the functioning of upper extremity is a questionable area [8, 24]. In cases with sub-acute stroke, patients present with varied symptoms and thus management of upper extremity and lower extremity functions along with the preservation of movements is a task to achieve. Many treatment strategies had been proved to affect the patients with sub-acute stroke among which three were taken in this study. Brunn storm approach was a traditionally used treatment regime for patients with stroke. Mirror neuron therapy is an advanced treatment strategy used for various conditions and in sub-acute stroke its use was yet to be discovered. Apart from these, mechanical vibration was used for tone facilitation in such patients.

Sub-acute stroke has seen to be highly correlated with reduced or diminished upper extremity functions and thus the procedures to be followed in such patients were also crucial. The primary aim of the present study was to determine the combined effect of Brunnstrom Approach, MV and MNT on upper limb function in patientswith sub-acute stroke. The results depicted calculated and analyzed data which showed statistically significant improvement in experimental group in all outcome measures whereas within group analysis improvement was significant in experimental group. The normality test was not calculated as the data was collected through Fugl Meyer Assessment of upper extremity and Motricity Index which were discrete measures. The data was represented as median and range which showed that results within groups were significant.

Minimal clinical important difference in Fugl Meyer Assessment upper extremity was 12.4 and Wrist & hand (4.9). [38].The objective of this study was to enhance the upper limb functions and strengths in patients with post sub-acute stroke anomalies. The Brunnstrom techniques help to revive handmovements and functioning of the upper extremity which was involved through facilitation of nervous system, producing changes of muscles spindle recruitment via the training of primary synergic pattern. Brunnstrom hand movement therapy helps to improve movement and strength of the upper extremity by proprioceptive stimulation. The activities in Brunnstrom Approach which was performed by patients were more patient centric and depended on prior hand functions for which treatment strategies were defined and followed.

FMA and MI scores showed that the four weeks of Brunnstrorm approach, Mirror Neuron Training along with Mechanical Vibration sequentially improve the upper limb function in experimental group. An article studying on patients with stroke which compared the Brunnstrom movement therapy and Motor Relearning Program using FMA scores as an outcome measure. The result of this showed that there was more improvement in hand function on Brunnstrom Hand Movement Therapy as compared to motor relearning program [10]. Wilcoxon signed rank test was used to evaluate within group analysis and thus all the outcomes revealed a significant p value (<0.05) concluding the treatment to be effective separately within each group which comes in light with the previous literatures that all the three interventions are efficient and proven to enhance the recovery of post stroke functions.

Mechanical vibration or Vibratory stimulation is useful for the treatment of motor disorders. Vibration stimulates the primary muscle spindle endings, causing Ia afferent impulses to be conducted to alpha motor neurons and IA inhibitory inter neurons in the spinal cord. This afferent pathway produces involuntary contraction in the vibrated muscle (that is, a tonic vibration reflex: TVR), and inhibits the antagonist muscle. Vibratory stimulation is therefore traditionally applied to the antagonist of the spastic muscle, in order to decrease the spasticity of a hemiplegic limb.An article investigated whether there is arelationship between direct application of vibratory stimuli and inhibition of spasticity on the hemiplegic upper limbs of post-stroke patients.The present study showsno significant changes in F wave parameters and Modified Ashworth Scale scores. The Stretch group showed a tendency to decrease in F-wave amplitude and F/M ratio immediately after the intervention, but not 30 min later. The Direct application of vibratory stimuli group showed significant improvements in F-wave parameters [20]. The direct application of vibratory stimuli has anti-spastic effects in the hemiplegic upper limbs of post stroke patients [20].

Another study conducted on patients with stroke found that the use of Whole Body Vibration (WBV) on motor function and grip strength in patients with sub-acute stroke was more effective than the use of ULC. Of course, motor function and grip strength improved in both groups, but it improved more in the WBV group. Therefore, task-oriented training after WBV effectively improved motor function and increased grip strength.2In an article, the study showed that the Repetitive focal muscle vibration(rMV) intervention can consistently improve motor outcome in a cohort of acute stroke patients. In light with the previous literatures, patients in the study clinically treated with rMV (VG) had a prominent clinical effect when compared to those accounted with a sham-rMV treatment regime as shown by improved NIHSS, Fugl- Meyer, and Motricity Index scores, regardless of the different baseline clinical stature, or the different stroke characteristics [4].

Mirror neuron training is a simple, inexpensive, and patient-

oriented treatment. Functional brain imaging studies conducted on healthy individuals have shown that the ipsilateral primary cortex excitability increases when observing the mirror image of the hand during unilateral hand movements. Mirror neuron training involves the superimposition of the reflections of healthy extremity movements on the affected extremity for the patient to observe them as if their extremity is moving. A video is placed on the front of the patient so that the healthy side image will be superimposed on the projection of the affected extremity. Thus, there is a visual illusion of increased movement ability of the paretic extremity. Authors conducted on a study on patients with stroke; this study showed that mirror therapy combined with conventional rehabilitation in stroke patients provides additive prospects with regard to upper extremity motor abilities and functioning. However, they did not see any superiority over conventional treatments in the FIM self-care score that evaluates the daily living activities of a person [9].

The trends show that there was significant increase in Fugl Meyer Assessment score in the fourth week in group 1 and FMA-UE score for between group analyses showed a p-value> 0.168. Fugl Meyer Assessment of 2nd week showed significant results in group 2 and 4th week results showed higher affinity of significant results in group 1. In this study, both groups showed improved outcome variables after treatments in measured time frame but experimental group depicted also statistically changed improvements as compared to control group in regards to hand abilities functions. We found clinically improvement among all outcome measures FMA-UEwhich was 21.5 and MI was 20.6. The Motricity index in group showed varied differences, in 2nd week assessment of Morticity index it was seen that group 1 had better results than group 2 and same was seen in group 1. The finding of our study provides significant improvement in both experimental and control group but in the term of clinical significance we found in experimental group. Considering the result of our present study accepted the alternative hypothesis and rejected our null hypothesis. Therefore, the present study contributes a successful positive factor for stroke rehabilitation.

4. Limitation of the Study

Unavoidable instrumental error.Due to short time duration unable to recruit all the samples.Lesser availability of patients due to single centered study.Earlier discharge of patients from hospital setting due to COVID-19.

5. Conclusion

This study concluded that when Brunnstorm Hand rehabilitation was added to combined approach of Mirror Neuron training along with mechanical vibration, the functioning of upper limb has been improved to a greater extent in patients with sub-acute stroke. Thus, the sufferers could be more benefitted with this approach and can lead an independent life.

Conflict of interest: None

Acknowledgements

We would like to thank M.M Institute of Physiotherapy and Rehabilitation for all the support.

References

[1] Oliveira MCB, Silva DRC, Cortez BV, janaina DMS. Mirror and vibration therapies effects on the upper limbs of hemiparetic patients after stroke: A pilot study. Rehabil Res Pract. 2018;2018(1):1-6.

[2] Ahn JY, Kim H, Park CB. Effects of whole-body vibration on upper extremity function and grip strength in patients with subacute stroke. Occup Ther Int. 2019;2019(3):1-5.

[3] Invernizzi M, Negrini S, Carda S, Lanzotti L, Cisari C, Baricich A. The value of adding mirror therapy for upper limb motor recovery of subacute stroke patients: A randomized controlled trial. Eur J Phys Rehabil Med. 2013;49(3):311-317.

[4] Toscano M, Celletti C, Vigano A. Short-term effects of focal muscle vibration on motor recovery after acute stroke : A pilot randomized sham-controlled study.Front Neurol. 2019;10(115):1-9.

[5] Manning AM, Vrbanac Z. Physical rehabilitation for the critically injured veterinary patient. Phy Ther for Spe Diag. 2014; 2014(2): 652-658

[6] Lee G. Whole-body vibration in horizontal direction for stroke rehabilitation: A randomized controlled trial. Med Sci Monit.2019;25(1):1621-1628.

[7] Ahn J, Kim H, Park C. Effects of whole-body vibration on upper extremity function and grip strength in patients with subacute stroke. OccupTher Int. 2019;2019(3):1-5. doi:10.1155/2019/5820952

[8] Nes IJWV, Latour H, Schils F, Meijer R, Kuijk A Van, Geurts ACH et al. Long-term effects of 6-week whole-body vibration on balance recovery and activities of daily living in the postacute phase of stroke. Stroke. 2006;37(4):2331-2335.

[9] Niu CM, Bao Y, Zhuang C. Synergy-based FES for post-stroke rehabilitation of upper-limb motor functions. IEEE Trans Neural Syst Rehabil Eng. 2019;27(2):256-264. doi:10.1109/TNSRE.2019.2891004

[10] Pandian S, Arya KN, Davidson EWR. Comparison of Brunnstrom movement therapy and motor relearning program in rehabilitation of post-stroke hemiparetic hand : A randomized trial. J Bodyw Mov Ther. 2012;16(3):330-337.

[11] Naghdi S, Ansari NN, Mansouri K. Neurophysiological and clinical study of Brunnstrom recovery stages in the upper limb following stroke. Brain Inj. 2010;24(11):1372-1378.

[12] Thant AA, Wanpen S, Nualnetr N. Effects of task-oriented training on upper extremity functional performance in patients with sub-acute stroke: A randomized controlled trial. J Phys Ther Sci.2019;31(1):82-87.

[13] Silva AT. Acute Effects of whole-body vibration on the motor function of patients with stroke. Am J Phys Med Rehabil. 2014;93(4):310-319.

[14] Park YJ, Park SW, Lee HS. Comparison of the effectiveness of whole body vibration in stroke patients : A meta-analysis. Biomed Res Int. 2018;2018(I):1-10.

[15] Lee HJ, Kim YM, Lee DK. The effects of action observation training and mirror therapy on gait and balance in stroke patients. J Phys Ther Sci. 2017;29(3):523-526.

[16] Carvalho D, Teixeira S, Lucas M. The mirror neuron system in post-stroke rehabilitation. Int Arch Med. 2013;6(41):1-7.

[17] Lim K, Lee H, Yoo J, Yun H, Hwang H. Efficacy of mirror therapy containing functional tasks in poststroke patients. Ann Rehabil Med. 2016;40(4):629-636.

[18] Nojima I, Mima T, Koganemaru S, Thabit MN, Fukuyama H. Human motor plasticity induced by mirror visual feedback. J Neurosci. 2012;32(4):1293-1300.

[19] Mao H, Li Y, Shan C. Effects of mirror neuron system-based training on rehabilitation of stroke patients. Brain Behav. 2020;10(2):1-7.

[20] Poenaru D, Cinteza D, Petrusca I, Cioc L, Dumitrascu D. Local application of vibration in motor rehabilitation - scientific and practical considerations.Maedica. 2016;11(3):227-231.

[21] Garrison KA, Winstein CJ, Aziz-zadeh L. The mirror neuron system : A neural substrate for methods in stroke rehabilitation. Neurorehab Neural Repair. 2010;24(5):404-412.

[22] Noma T, Matsumoto S, Etoh S, Shimodozono M, Kawahira K. Anti-spastic effects of the direct application of vibratory stimuli to the spastic muscles of hemiplegic limbs in post-stroke patients. Brain Inj. 2009;23(7-8):623-631.

[23] Grefkes C, Fink GR. Recovery from stroke: Current concepts and future perspectives.Neurol Res Pract. 2020;2(1):1-10.
[24] Gupta N , Goel V , Rani P , Rani P, Prakash T. To study the efficacy of tactile strengthening of muscles on postural sway and balance. Indian J Physiother Occup Ther. 2017;11(2):1-6.
[25] Gurbuz N, Afsar SI, Ayaş S, Nur S, Cosar S. Effect of mirror therapy on upper extremity motor function in stroke patients : A randomized controlled trial. J Phys Ther Sci. 2016;28(9):2501-2506.
[26] Pollock A, Farmer SE, Brady MC. Interventions for improving upper limb function after stroke. Cochrane Database Syst Rev. 2014;2013(11):1-138.
[27] Pandian JD. Stroke epidemiology and stroke care services in india. J Stroke. 2013;15(3):128-134.
[28] Kim J, Lee S. Whole-body vibration combined with treadmill training improves walking performance in post-stroke patients : A randomized controlled trial. Med Sci Monit. 2017;23:4918-4925.
[29] Kim H, Her J, Ko J. Reliability , concurrent validity , and responsiveness of the Fugl-Meyer Assessment (FMA) for hemiplegic patients. J Phys Ther Sci. 2012;24(9):893-899.
[30] Bohannon RW. Motricity index scores are valid indicators of paretic upper extremity strength. J Phys Ther Sci. 2014;11(2):59-61.
[31] Portney LG, Watkins MP. Foundation of Clinical Research Application to Practice. 3rd Edition. F.A. Davis Company; 2013. 648-649
[32] Sanford J. Reliability of the Fugl-Meyer Assessment for testing motor performance in patients following stroke.Phys Ther. 1993;73(7):36-43.
[33] Fayazi M, Dehkordi SN, Dadgoo M, Salehi M. Test-retest reliability of Motricity Index strength assessments for lower extremity in post stroke hemiparesis. Med J Islam Repub Iran. 2012;26(1):27-30. pmid: 23483112
[34] 34. Gladstone DJ, Danells CJ, Black SE. The Fugl-Meyer Assessment of motor recovery after stroke: A critical review of Its measurement properties. Neurorehabil Neural Repair. 2002;16(3):232-240.
[35] Keefe DJO. Brief Report : Post hoc power , observed power , a priori power , retrospective power , prospective power , achieved power : sorting out appropriate uses of statistical power analyses. Commun Methods Meas. 2010;24(4):291–9.
[36] 36. Boutron I, Moher D, Altman DG, Schulz KF, Ravaud P. CONSORT statement to randomized trials of nonpharmacologic treatment. Ann Intern Med. 2020;167(1):40–7.
[37] 37. Ikeda N, Otsuka S, Kawanishi Y, Kawakami Y. Effects of instrument-assisted soft tissue mobilization on musculoskeletal properties. Med Sci Sports Exerc. 2019;51(10):2166–72.
[38] 38. Hiragami S, Inoue Y, Harada K. Minimal clinically important difference for the Fugl-Meyer assessment of the upper extremity in convalescent stroke patients with moderate to severe hemiparesis. J Phys Ther Sci. 2019;31(11):917-921.