International Journal of Yoga, Physiotherapy and Physical Education
ISSN: 2456-5067; Impact Factor: RJIF 5.24
Received: 03-08-2019; Accepted: 05-09-2019
www.sportsjournal.in
Volume 4; Issue 6; November 2019; Page No. 10-15

Effect of home exercise program coupled with modified rood's approach on the spasticity of post stroke patient

Kuki Bordoloi[1], Rup Sekhar Deka[2]
[1] PhD Scholar-Srimanta Shankardeva University of Health Sciences, Guwahati, Assam Narakasur Hilltop, Bhangagarh, Guwahati, Assam, India
[2] Associate professor, Department of Anatomy, Jorhat Medical College, Jorhat, Assam, India

Abstract
Introduction: Spasticity is one of the most common complications of stroke. This occurs due to increase in the muscle tone and hyperactive reflexes, which leads to functional impairment. Since, stroke rehabilitation takes prolonged duration of time, hence, home base exercise therapy is usually recommended to patients after their discharge from hospital. Moreover, Rood's approach is a neurophysiological approach which is designed to ameliorate the after effects of stroke through neuro-facilitation.
Methodology: The aim of this study was to compare the effects of a Home Exercise Program (HEP) coupled with and without Rood's approach on the muscle tone of stroke patients after 3 months of physical therapy. A pre and post experimental study was done at Gauhati Medical College & Hospital, Assam (India). A total of 236 hemiplegic subjects with intracerebral haemorrhagic stroke were considered who were divided into two groups – Group A: Patients receiving only HEP and Group B: Patients receiving both HEP and neuro-facilitation based on Rood's approach. The outcome variable measuring muscle tone (spasticity) was Modified Ashworth Scale (MAS).
Result: It was observed after treatment of 3 months that the MAS was significantly improved in terms of decreased muscle tone in case of patients receiving HEP with Rood's approach (Group B) when compared to the group receiving HEP alone (Group A) ($p<0.05$).
Conclusion: Although it was found that both the groups decreased the muscle tone, but HEP with Rood's approach was found to be more effective in decreasing the spasticity i.e. decrease muscle tone. This shows that a neuro-facilitation technique such as Rood's approach is an effective technique for stroke rehabilitation.

Keywords: Rood's approach, home exercise program (HEP), physiotherapy, intracerebral haemorrhage, stroke, muscle tone

1. Introduction
Stroke is one of the most leading causes of disability among people throughout the world. Recent studies reveal that every year 15 million people worldwide suffer from stroke. Some recover from the disease while most of others are left permanently disabled [1].Physiotherapy is paramount and the only key towards eliminating disability in stroke patients. Among all other problems faced by stroke patients, spasticity is one of the most common complications of a upper motor neuron disease. This occurs due to a pathological increase in the muscle tone and hyperactive reflexes leading to functional limitations in the patient [2]. It is a positive sign of upper motor neuron damage syndrome which can be defined as a velocity dependent increase in resistance of a passively stretched muscle with exaggerated tendon jerks, resulting in hyper-excitability of the stretch reflex. This leads loss of mobility, abnormal limb posture, and excessive contraction of antagonist muscles [3]. Physical therapy is usually used in the treatment of spasticity emanating from stroke. However, subsequent to their discharge from hospital, the patients are usually recommended a home based exercise programme i.e. HEP as stroke rehabilitation process is a prolonged process (cannot be carried out usually in an acute care hospital). Many stroke patients are deprived of stroke rehabilitation programmes due to the lack of awareness, remoteness of their home from the city and financial constraints. Hence, adherence to HEP is a primary reason for successful rehabilitation and ability of the patients to carry out their activities of daily living.
Rood's approach is a neuro-physiological approach that was developed by Margaret Rood in 1940 [4-5]. Her theory originated in the 1940s and has undergone many revisions over the years. The Rood's approach is based on four basic principles–(1) motor output is dependent upon sensory input, (2) motor response follow a normal developmental sequence,(3) purposeful activity and (4) repetition or practice for motor learning [6]. According to Rood's approach, appropriate sensory stimuli can give desired muscular response which can activate or deactivate the receptor by facilitation or inhibition [4-6]. Rood described four types of receptors- proprioceptive receptors, exteroceptive receptors, vestibular receptors and special sense organs. This technique categorized the light work muscles (mobilizers) i.e. primarily the flexors and adductors used for skilled movement patterns, and the heavy work muscles (stabilizers) as principally the extensors and abductors used for postural support [7,8]. Using these concepts of light and heavy work, Rood outlined the normal developmental sequence by using the following order of activation of muscles groups [9]. However, the developmental sequence of Rood's approach is generally

accepted as outdated because other developmental studies show that the normal human development depends on perception, action, cognition, exploration, inherited tendencies and experience dependent learning [10, 11]. These researches showed that the developmental motor sequence was neither followed invariably by developing children nor adhered to by adults when rising from supine to erect posture [12]. Hence, in this research the ontogenic developmental sequence part has been excluded [12].

Neurophysiological studies reported earlier have shown that the increase in the muscle tone reaches its maximum between 1 and 3 months after stroke [13, 14]. In neurological rehabilitation, normalization of muscle tone is a big challenge in post-stroke individual. It is also observed that some group of muscles often developed more spasticity [15]. Hence, in this study, focus was given on those few groups of muscle which are prone to develop spasticity. Thus, this study was designed to assess the changes in muscle tone and effectiveness of HEP with and without Rood's approach in normalizing the muscle tone in cases of post intracerebral hemorrhage. Comparative analysis was done using two groups – one provided with only HEP while the other was given HEP along with neuro-facilitation by Rood's approach.

2. Materials and method

A pre and post experimental study was conducted at the department of Neurology, Gauhati Medical College & Hospital (GMCH), Assam (India). 236 hemiplegic patients with intracerebral haemorrhagic stroke were selected from GMCH based on the inclusion and exclusion criteria. Inclusion criteria consisted of haemorrhagic stroke with supratentorial haematoma with hemiplegia, muscle power 0-3 muscle grade by manual muscle testing, age between 20-65 years. The exclusion criteria are uncontrolled hypertension, severe dysphasia or cognitive impairment, had previously demonstrated disability in self-care and the patient had been living in a nursing home prior to the stroke. The patients were divided in to two groups. Both the groups (Groups A and B) were given a HEP which will include range of motion exercises, strengthening, stretching, weight bearing, balance and coordination exercise. One group out of the two (Group B) were additionally taught the exercises based on the Rood's approach which included facilitation and inhibition with the help of cutaneous and proprioceptive stimulation, sensory stimulation, task specific activity and repetition of the same exercises. The patients visited the department of neurology every 15 days for three months, for modifications in the exercises as per change in the condition; the muscle tone was assessed using the Modified Ashworth Scale (MAS) after 3 months. The effectiveness of home exercise programme in decreasing the muscle tone was determined statistically and compared with the group of patients received both HEP and neuro-facilitation using Rood's approach. This would provide a knowhow on the effectiveness of Rood's approach in decreasing the muscle tone (spasticity) in stroke survivors.

2.1 Home Exercise Programme (HEP)

All patients started with range of motion exercises, strengthening exercises (once the muscle power reached a grade 3, the caregiver starts helping the patients perform resistive exercises), stretching exercises and weight bearing exercises. For weight bearing exercise given to the upper limbs, the patients were instructed to sit on the bed with hands placed on bed and then they had to press the bed with the palm to raise the body in the upward direction. For weight bearing exercises in the lower limbs, the attendants were asked to make the patient stand with support. Balance and coordination training were also provided to all the patients.

2.2 Rood's Approach

2.2.1 For facilitation

Quick stretch, resistance, tapping, quick icing, fast brushing, light touch, traction, approximation and heavy joint compression was given.

2.2.2 For inhibition

Inhibitory stimulus for desired muscle group and facilitatory for the opposite muscle group. Prolonged stretch, inhibitory tendon pressure, prolonged ice, slow rolling was given.

Along with the stimulation, patients were also advised to do some repetitive purposeful activity; *viz.* (1) for upper limb - wipe the table for 5 minutes, grasp a glass and release the glass, touch a wall at the shoulder level and touch his/her cheek, touch hair, and slide a ball with the help of extensor aspect of forearm; (2) For lower limb - sitting to standing with support, kick a ball, standing to half sitting and walk with support.

3. Outcome measures

The muscle tone was assessed by Modified Ashworth Scale (MAS) after 3 months of physiotherapy treatment. The effectiveness of the HEP along with facilitation based on Rood's approach in decreasing the muscle tone of the patients was determined.

4. Statistical analysis

The sample size was calculated using the data from The Glasgow Augmented Physiotherapy Study (GAPS) Group[16]. As per their study, an expected mean improvement of the Rivermead Mobility Index (RMI) score was 9.7(+/-3.3) for the intervention Group (augmented physiotherapy) and 8.1 (+/-3.1) for the control Group (standard physiotherapy). Setting $\alpha = 0.05$ (2-tailed) for the two-sample t-test, with 80% statistical power to detect the accurate sample size. The calculated *n* value was 106 (per arm), making the total sample size to be 212. Hence, the total sample size for this study was taken as 236, i.e. 212 + 24, where the additional 24 more samples are added to overcome the possibility of non-responds/ missing subjects. Hence, the sample size for the study was considered to be 236.

The data were analyzed by the statistical software SPSS 20.0. The intergroup data of Modified Ashworth Scale was analyzed using the paired t-test, and the intragroup analysis was done by an independent t-test. The level of significance set for this study was set at 95% ($p < 0.05$).

5. Result

236 participants were recruited for the study based on inclusion and exclusion criteria, and their baseline characteristics were recorded (Table 1). Subsequently, they were divided into Group A (control) and Group B (intervention), whereby they have prescribed their quota of HEP (with and without Rood's approach) for three months. The follow-up ended after three months. The follow up of a total of 33 numbers of patients were missed during the study (Table 1).

Table 1: Baseline Characteristics

		Randomized n (%)		Loss on follow up n (%)	
		236(100)		38(16.1)	
		Group A	Group B	Group A	Group B
		118(50)	118(50)	20(8.5)	18(7.6)
Age, Mean (SD)		50.65(±9.8)	51.91(±9.1)	52.70(±9.5)	53.06(±8.4)
Sex (%)	Male	76(64.4)	72(61)	15(75)	11(61.1)
	Female	42(35.6)	46(39)	5(25)	7(38)
Work (%)	Service	20(16)	25(21)	5(25)	5(27)
	Business	18(15)	39(33)	2(10)	5(27)
	Farming	40(33)	27(22)	8(40)	6(33)
	House wife	39(33)	27(22)	5(25)	2(11)
	Retired	1(0.8)	0(0)	0(0)	0(0)
Education (%)	No school	22(18)	27(22)	3(15)	5(27)
	Primary	27(22)	31(26)	2(10)	5(27)
	Secondary	35(29)	25(21)	4(20)	4(22)
	High school	29(24)	23(19)	10(50)	3(16)
	College	5(4.2)	12(10)	1(5.0)	1(5.6)

5.1 Effectiveness of the HEP with and without Rood's approach on Muscle Spasticity

The muscle spasticity was measured using the Modified Ashworth Scale for the muscles – shoulder adduction, elbow flexor, wrist flexors, finger flexors, hip adductors, knee extensors and ankle planter flexors. In order to evaluate the effectiveness of HEP with and without Rood's Approach in muscle spasticity using Modified Ashworth Scale, the data were analyzed in three phases. i.e. comparative analysis of the muscle tone on the first day before treatment between two groups (Table 2), comparative analysis of the muscle tone between before treatment and after 3 months of treatment for each group (Table 3) in two groups and lastly, comparative analysis of the muscle tone after 3 months of treatment between two groups (Table 4).

Table 2: Pre-test comparison of muscle tone in the two groups

Muscle Group	Evaluation Day of randomization	Mean	SD	t value	p value
Shoulder Adduction	Group A	0.47	0.80	0.49	0.625^{NS}
	Group B	0.53	0.79		
Elbow Flexor	Group A	0.56	0.99	0.33	0.739^{NS}
	Group B	0.60	0.96		
Wrist Flexors	Group A	0.55	0.98	0.34	0.735^{NS}
	Group B	0.59	0.95		
Finger flexors	Group A	0.51	0.81	0.73	0.468^{NS}
	Group B	0.58	0.80		
Hip adductors	Group A	0.64	0.88	0.29	0.776^{NS}
	Group B	0.61	0.94		
Knee extensors	Group A	0.53	0.81	0.33	0.744^{NS}
	Group B	0.57	0.78		
Ankle planter flexors	Group A	0.63	0.99	0.27	0.790^{NS}
	Group B	0.59	0.96		

NS – Not significant, * - <0.05

From the pretest comparative analysis of the mean values of muscle tone, it was observed that the pre-treatment tone in Group A ranged from 0.58±0.99 to 0.49±0.782 and in Group B it ranged from 0.61±0.94, to 0.53±0.79 (refer Table 2). There was no significant difference in the pre-treatment muscle tone in both groups (p>0.05).

Table 3: Pre-test and post-test comparison of muscle tone in two groups

Muscle Group	Group	Evaluation	Mean N	SD	t value	p value
Shoulder Adductors	Group A	Pre-test	0.52	0.84	14.59	<0.001**
		Post-test	2.02	0.80		
	Group B	Pre-test	0.52	0.79	12.25	<0.001**
		Post-test	1.74	0.63		
Elbow Flexor	Group A	Pre-test	0.61	1.03	16.51	<0.001**
		Post-test	2.57	0.73		
	Group B	Pre-test	0.60	0.94	14.47	<0.001**
		Post-test	2.24	0.75		
Wrist Flexors	Group A	Pre-test	0.60	1.01	16.12	<0.001**
		Post-test	2.44	0.70		
	Group B	Pre-test	0.60	0.94	14.22	<0.001**
		Post-test	2.21	0.73		
Finger Flexors	Group A	Pre-test	0.56	0.85	16.30	<0.001**
		Post-test	2.36	0.83		
	Group B	Pre-test	0.59	0.78	16.92	<0.001**
		Post-test	2.16	0.68		
Hip Adductors	Group A	Pre-test	0.63	0.88	15.61	<0.001**
		Post-test	2.45	0.73		
	Group B	Pre-test	0.62	0.94	16.28	<0.001**
		Post-test	2.23	0.53		
Knee extensors	Group A	Pre-test	0.57	0.84	18.22	<0.001**
		Post-test	2.50	0.76		
	Group B	Pre-test	0.58	0.76	19.56	<0.001**
		Post-test	2.51	0.75		
Ankle planter flexors	Group A	Pre-test	0.67	1.03	15.48	<0.001**
		Post-test	2.46	0.58		
	Group B	Pre-test	0.60	0.94	17.23	<0.001**
		Post-test	2.79	0.76		

NS – Not significant, * - <0.05, ** - <0.01

Table 3 depicts pre-test and post-test comparison of muscle tone in the two groups**.** At the end of the study, both groups demonstrated significantly difference (p<0.05) in the muscle tone for all the upper limb and lower limb muscle groups. Mean pre-treatment muscle tones in Group A ranged from 0.67±1.03 to 0.52±0.84 and in Group B it ranged from 0.62±0.94 to 0.52±0.79. Mean post-treatment muscle tones in Group A ranged from 2.57±0.73 to 2.02±0.80 and in Group B it ranged from 2.79±0.76 to 1.74±0.63 (refer Table 3).

Table 4: Post-Test Comparison of Muscle tone in Two Groups

Muscle Group	Evaluation after 3 months	Mean	SD	t value	p value
Shoulder Adduction	Group A	2.02	0.799	2.678	0.008*
	Group B	1.74	0.631		
Elbow Flexor	Group A	2.57	0.732	3.09	0.002*
	Group B	2.24	0.747		
Wrist Flexors	Group A	2.44	0.704	2.214	0.028*
	Group B	2.21	0.732		
Finger Flexors	Group A	2.36	0.826	1.853	0.065*
	Group B	0.216	0.684		
Hip Adductors	Group A	2.45	0.734	2.338	0.02*
	Group B	2.23	0.533		
Knee extensors	Group A	2.5	0.763	0.48	0.962NS
	Group B	2.51	0.752		
Ankle planter flexors	Group A	2.46	0.577	3.378	0.001*
	Group B	2.79	0.763		

NS – Not significant, * - <0.05

On comparison between the two groups for both upper and lower limbs at the end of 3 months, group B demonstrated significantly better effect than group A on the decrease in muscle tone of shoulder adductors, elbow flexors, wrist flexors, finger flexor and hip adductors except knee extensors and finger flexors. The mean post-treatment muscle tones in Group A ranged from 2.57±0.732 to 2.02±0.799 and in Group B it ranged from 2.79±0.763 to 1.74±0.631 (refer Table 4).

6. Discussion

It was observed from the results that a significant difference exists between the two groups ($p<0.05$) after 3 months of treatment. It was observed that in maximum muscle groups, muscle tone increased after three months in comparison to the first day before treatment. This is due to upper motor neuron lesion. There was no significant difference found in the pre-treatment muscle tone for both the groups. Although it was observed that the muscle tone increased in both the groups (for most muscle groups), the muscle tone of Group B patients (receiving HEP and Rood's approach) were significantly lower than those of Group A after a period of 3 months. This added decrease in the muscle tone was due to the fact that one of the basic principle of Rood's approach was "Normalization of tone using sensory stimuli".Various literatures found direct or indirect effects of Rood's approach in normalizing the muscle tone. According to Rood's theory, sensory stimulation can facilitate and inhibit muscle activity which helps in the normalization of muscular tone. Different kinds of sensory technique can be used in home setting such as brushing, stretching (quick or prolonged), icing (quick icing or prolonged), slow stroking, neutral warmth, tendon pressure, joint approximation, heavy joint compression, traction etc that can cause this effect.

Brushing helps to normalized the muscle tone in post-stroke patients [17]. This fact was also reinforced by the research of Patel and Vekariya, where they found an inhibitory effect on H-reflex excitability and decrease in the muscle tone after brushing. This can be used as one of the facilitatory technique for eliciting muscle tone in neurological disorders [18]. Linkous *et al*., found that tactile stimulation can enhance muscular tone in hypotonic disorder patients [19]. In this research, they observed that tactile stimulation such as brushing, stretching, etc applied on upper limb extensors and lower limb flexors muscle group helped in decreasing the muscle tone for antisynergic muscle.

Stretching has been extensively used in clinical practice, which has abundance benefit in decreasing muscle tone. Numerous researches done in this domain supports the cause of stretching given in order to decrease the muscle tone (spasticity) in patients [20-30].

As reported by El-Maksoud *et al*., prolonged icing with ice packs decrease spasticity and increased the active range of motion [31]. Harlaar *et al*., reported that prolonged icing has an antispastic effect by increasing the pain threshold and consequently reducing receptor sensitivity of low-threshold afferents [32].

Slow stroking also helps to reduce spasticity [33]. According to Brouwer and de Andrade, 3 minutes of slow stroking on posterior primary rami can reduce alpha-motoneuron excitability. This can in return, reduce spasticity[34]. Additionally, tendon pressure is also used to reduce muscle tone. Leone and Kukulka found that tendon pressure decreases the H-reflex which is an indirect measure of motoneuron excitability. They suggested that tendon pressure can be used to reduce muscle tone in hemiparetic patients [36-37].

Numerous researches discussed above show that Rood's 'normalization of tone' with the use of sensory stimuli is an important part of motor recovery. The various techniques of Rood's approach (*viz*. brushing, stretching, icing, slow stroking, tendon pressure etc) employed in the present study significantly contributes to the enhanced decrease in the muscle tone in case of patients receiving neuro facilitation via Rood's approach in addition to HEP.

7. Limitations of the study

- All types muscle groups were not evaluated.
- Small sample size.
- Follow-ups after long time intervals.
- Shorter evaluation duration of 3 months only.

8. Conclusion

A comparative study was done to determine the efficacy of Rood's approach towards decreasing muscle tone in post-stroke rehabilitation. It is observed that when compared with HEP alone, HEP along with neuro-facilitation using Rood's approach is significant in decreasing the muscle tone (decreasing the MAS score). The main principles prescribed by Rood's approach in treatment might be the cause of this decrease in the muscle tone *viz*. proprioceptors stimulation, exteroceptive stimulation, purposeful activity and repetition of movement. Facilitation or inhibition of proprioceptors, exteroceptors, vestibular and special sense organs excited the anterior horn cell of spinal cord, which helped in normalizing the muscular tone and motor recovery. This suggests that Rood's approach, along with the HEP, is instrumental in decreasing muscle tone when compared with HEP alone. The effective decrease in muscle tone also leads to an increased motor activity and decrease in the disability of the patients.

9. Acknowledgments

The authors would like to thank the patients and caregivers that participated in this trial. The authors would also like to thank the GMCH hospital doctors and staff involved in assisting the authors in conducting the study.

10. Reference

1. Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A, *et al*. An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/ American Stroke Association. Stroke. 2013 Jul; 44(7):2064-89.
2. Rekand T. Clinical assessment and management of spasticity: a review. Acta Neurologica Scandinavica. 2010; 122:62-6.
3. Young RR. Spasticity: a review. Neurology. 1994; 44:512–520.
4. Rood MS. Neurophysiological reactions as a basis for physical therapy. Physical Therapy Review. 1954; 34:444-449.
5. Rood MS. Neurophysiological mechanisms utilized in the treatment of neuromuscular dysfunction. American Journal of Occupational Therapy. 1956; 10:220-225.
6. Trombly C, Levit K, Myers BJ. Remediating motor control and performance through traditional therapeutic approaches. Occupational Therapy for Physical Dysfunction, 4th ed. Philadelphia: Williams & Wilkins, 1997, 437-446.
7. Rood MS. The use of sensory receptors to activate, facilitate, and inhibit motor response, autonomic and somatic, in developmental sequence. In C. Sauely (Ed.), 1962.
8. Goff B. The application of recent advances in neurophysiology to Miss M. Rood's concept of neuromuscular facilitation. Physiotherapy. 1972 10; 58(12):409.
9. Heiniger MC, Randolph SL. Neurophysiological concepts in human behavior: The tree of learning. Mosby Incorporated, 1981.
10. Johnson MH. Developmental Cognitive Neuroscience. Cambridge: Blackwell Publishers Ltd, 1997.
11. Thelen E. Motor development: A new synthesis. American psychologist. 1995; 50(2):79.
12. Bordoloi K, Deka RS. Scientific reconciliation of the concepts and principles of rood approach. Int J Health Sci Res. 2018; 8(9):225-234.
13. Teasell RW, Heitzner JD. The painful hemiplegic shoulder. Phys Med Rehabil State Art Rev. 1998; 12:489–500.
14. Bhakta BB. Management of spasticity in stroke. Br Med Bull. 2000; 56:476–485
15. Wissel J, Schelosky LD, Scott J. *et al*. Early development of spasticity following stroke: a prospective, observational trial J Neurol. 2010; 257:1067-1072
16. Glasgow Augmented Physiotherapy Study (GAPS) Group. Can augmented physiotherapy input enhance recovery of mobility after stroke? A randomized controlled trial. Clinical rehabilitation. 2004; 18(5):529-37
17. Nielsen AJ, Grady S, Sussman C, Henry M, Feichtmann C, Dodge M, *et al*. A Brushup on Rood's Technique. Physical therapy. 1986 Apr 1; 66(4):579-80.
18. Patel GJ, Vekariya NN. The effect of Manual Skin Brushing on H-Reflex Amplitude in Normal Human Subjects. Indian Journal of Physiotherapy and Occupational Therapy. 2014 Apr 1; 8(2):178.
19. Linkous LW, Stutts RM. Passive tactile stimulation effects on the muscle tone of hypotonic, developmentally delayed young children. Perceptual and motor skills. 1990; 71(3):951-4.
20. Burke D, Andrews C, Ashby P. Autogenic effects of static muscle stretch in spastic man. Archives of neurology. 1971 Oct 1; 25(4):367-72.
21. Odeen I, Knutsson E. Evaluation of the effects of muscle stretch and weight load in patients with spastic paraplegia. Scandinavian Journal of Rehabilitation Medicine. 1981; 13(4):117-21.
22. Odeen I. Reduction of muscular hypertonus by long-term muscle stretch. Scand. J. Rehab. Med. 1981; 13:93-99.
23. Robinson KL, McComas AJ, Belanger AY. Control of soleus motoneuron excitability during muscle stretch in man. Journal of Neurology, Neurosurgery & Psychiatry. 1982 Aug 1; 45(8):699-704.
24. Tremblay F, Malouin F, Richards CL, Dumas F. Effects of prolonged muscle stretch on reflex and voluntary muscle activations in children with spastic cerebral palsy. Scandinavian Journal of Rehabilitation Medicine. 1990; 22(4):171-80.
25. Richards CL, Malouin F, Dumas F. Effects of a single session of prolonged plantarflexor stretch on muscle activations during gait in spastic cerebral palsy. Scandinavian journal of rehabilitation medicine. 1991; 23(2):103-11.
26. Vujnovich AL, Dawson NJ. The effect of therapeutic muscle stretch on neural processing. Journal of Orthopaedic & Sports Physical Therapy. 1994 Sep; 20(3):145-53.
27. Childers MK, Biswas SS, Petroski G, Merveille O. Inhibitory casting decreases a vibratory inhibition index of the H-reflex in the spastic upper limb. Archives of physical medicine and rehabilitation. 1999 Jun 1; 80(6):714-6.
28. Avela J, Kyrolainen H, Komi PV, Rama D. Reduced reflex sensitivity persists several days after long-lasting stretch-shortening cycle exercise. Journal of Applied Physiology. 1999 Apr 1; 86(4):1292-300.
29. Tsai KH, Yeh CY, Chang HY, Chen JJ. Effects of a single session of prolonged muscle stretch on spastic muscle of stroke patients. Proceedings-National Science Council Republic of China Part B Life Sciences. 2001; 25(2):76-81.
30. El-Maksoud GM, Sharaf MA, Rezk-Allah SS. Efficacy of cold therapy on spasticity and hand function in children with cerebral palsy. Journal of Advanced Research. 2011 Oct 1; 2(4):319-25.
31. Harlaar, JJ Ten Kate, AJH Prevo, TW Vogelaar, GJ Lankhorst J. The effect of cooling on muscle co-ordination in spasticity: assessment with the repetitive movement test. Disability and rehabilitation. 2001 Jan 1; 23(11):453-61.
32. Bassett SW, Lake BM. Use of cold applications in the management of spasticity: report of three cases. Physical Therapy. 1958 May 1; 38(5):333-4.
33. O'SULLIVAN SB. Strategies to improve motor control and motor learning. Physical Rehabilitation, Assessment and Treatment, 2001, 363-410.

34. Brouwer B, de Andrade VS. The effects of slow stroking on spasticity in patients with multiple sclerosis: a pilot study. Physiotherapy Theory and Practice. 1995 Jan 1; 11(1):13-21.
35. Matsumoto S, Kawahira K, Etoh S, Ikeda S, Tanaka N. Short-term effects of thermotherapy for spasticity on tibial nerve F-waves in post-stroke patients. International journal of biometeorology. 2006 Mar 1; 50(4):243.
36. Leone JA, Kukulka CG. Effects of tendon pressure on alpha motoneuron excitability in patients with stroke. Physical therapy. 1988 Apr 1; 68(4):475-80.
37. Kukulka CG, Fellows WA, Oehlertz JE, VanderWilt SG. Effect of tendon pressure on alpha motoneuron excitability. Physical therapy. 1985 May 1; 65(5):595-600.