

REVIEW ARTICLE

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EFFECT OF STRETCHING TO RELIEVE SPASTICITY IN NEUROLOGICAL CONDITIONS- A SYSTEMATIC REVIEW**Aditi Hari Bhilwade¹ , Dr. Suvarna Shyam Ganvir(PhD)²**¹MPT 1st year Student,²HOD and Professor, Department of Neurophysiotherapy,

DVVPF's College of Physiotherapy, Ahmednagar

ABSTRACT:

BACKGROUND- Stretching is most commonly used technique to reduce spasticity. There are various techniques in reducing spasticity in neurological conditions. **OBJECTIVE-** To investigate the literature evidence for the effect of stretching on spasticity in neurological conditions. **DATA SOURCES-** A systematic review of all literature found in last 20 years are related to the different techniques of stretching to reduce spasticity (keywords: stretching, spasticity) from PubMed, Google scholar, Science direct and Cochrane database of systematic reviews. Electronic searching was used to find the source literature using definitive keywords. **CONCLUSION-** There are the wide variety of the studies investigating the effect of stretching to relieve spasticity in neurological conditions. The further studies can be done to investigate the long-term effects of stretching to reduce spasticity.

KEY WORDS: Stretching, Spasticity , PhysiotherapyReceived 10th June 2020, Accepted 20th June 2020, Published 30th June 2020www.vimsptcr.in**CORRESPONDING AUTHOR**

BHILWADE ADITI HARI

MPT 1st year

Department of Neurophysiotherapy ,

DVVPF'S ,College of Physiotherapy,

Ahmednagar. 414111. (M.S.)

E-mail: - aditibhilwade25@gmail.com**Phone No:** +91 8689800351

INTRODUCTION

Spasticity is a motor disorder which is characterized by velocity dependent increase in tonic stretch reflexes with exaggerated tendon jerks resulting from hyper excitability of the stretch reflex.¹ In spasticity, the faster the muscle is stretched, greater is the resistance. Spasticity leads to impairment of function and limitation of activity.²

The lesions in the descending motor pathways causes imbalance in neural activity which lead to positive and negative phenomena. The spasticity is the one of the positive phenomena and develops in upper motor neuron syndrome such as stroke, brain injury and multiple sclerosis.¹

The physical features of spasticity are mainly pain, involuntary movements, abnormal postures, and resistance to movement which leads to secondary problems such as change in muscle length which causes the development of contractures and deformity.³

Spasticity results from alteration in the balance of inputs from reticulospinal and other descending pathways to the motor and interneural circuits of the spinal cord. When the muscle is stretched, the primary afferent fibers that supply the intrafusal fibers of the muscle spindle gets excited and this triggers the monosynaptic excitatory connection with the α motor neuron which supply the stretched muscle and results in contraction of the stretched muscle and excitatory connections with α motor neuron that supplies synergistic muscle. The afferent fibers has a monosynaptic connection with a spinal interneuron that results in an inhibition of antagonist muscle and this controlled contraction of the agonist and reciprocal inhibition of antagonist muscle is impaired in upper motor neuron syndrome.³

The lesions in brain and spinal cord causes spasticity mainly by different mechanism. When spasticity is caused by brain lesion then it is associated with rapid response of the antigravity muscles that are flexors of upper extremity and extensors of lower extremity and when spasticity is caused by spinal cord lesions is associated with slow response and result in increased response of flexors and extensors.⁴

According to several studies the prevalence of spasticity in patients with stroke has been reported as 19% after 3

months and 20% after 18 months⁵ and in people with multiple sclerosis rate of spasticity along the course has been reported as 47%- 70%.⁶

Spasticity and its management are the major problem in rehabilitation. There are three major approaches in the management of spasticity and currently used are pharmacological, surgical and physical. So, the physical therapy remains the most practical form of the treatment, the treatment includes the stretching, PROM, MFR, Vibratory stimulation etc.⁷ The stretching is first currently used technique in the physical management of spasticity.

Stretching is the process of elongation and mainly used to reduce spasticity. Stretching leads to increase in extensibility of soft tissues by mechanism that involves viscous deformation and structural adaptations of muscles and soft tissues.⁸ The structures which are put under tension are muscle, tendon, connective tissues, vascular, dermal and neural tissue.⁹ The aim of stretching is to normalize the tone, to reduce the pain, to increase the soft tissue extensibility and to improve function.¹⁰

Stretching leads to decrease stiffness, improves movement control, increases in motor neuron excitability, decreases development of contracture, increases range of motion, improves gait pattern and also reduces the energy during walking.¹²

Stretching technique can be given in various forms which includes- passive stretching, active stretching, prolonged stretching, ballistic stretching, isokinetic stretching and isotonic stretching and also in various ways depending upon intensity of stretch that is amount of tension that can be applied to the structure which can kept constant or can be varied.^{11,12} It also depends upon velocity, repetition of stretch, duration and frequency of stretch. The structure that are being stretched depends upon the location and the position of the stretch which to be performed.¹The prolonged stretching is defined as the process of placing particular body segments into a position that will lengthen, or elongate, the muscles and soft tissues over an extended period of time. In prolonged muscle stretching, casting is widely used technique which helps in maintaining the limbs in stretched position for prolonged time.¹³

Children depends upon various factors such as age of the child, severity of spasticity and contracture, tolerance of the stretch, cognitive level of the child and functional outcomes of the child depending upon its Gross motor function classification score.¹⁵

According to Song Jun et al, they did study on the effect of hand stretching device to reduce spasticity in chronic hemiparetic stroke patients. They used resting hand splint along with hand and finger stretcher as a stretching device and outcome measure used was modified ashworth scale. So, they found that stretching device effectively reduces hand spasticity in patients with chronic hemiparetic stroke.¹⁶

According to some authors and studies it is stated that stretching followed by passive exercise reduces hyperactive stretch reflexes, slowly sustained stretch helps in reducing the contracture and prolonged muscle stretch reduces the motor neuron excitability.

The intervention to decrease spasticity is widely vary with the aims and possibilities. This systematic review aims at examining the effect of stretching to relieve spasticity in neurological conditions.

METHODOLOGY

Search Strategy

A systematic review was undertaken of all literature concerning the effect of stretching to reduce spasticity. The keywords: Stretching and spasticity were entered into PubMed, Google scholar, Science direct, Cochrane library. The electronic search was done by cross checking the references list of all relevant articles.

Selection Criteria

The population which was selected were adults and children with spasticity developed after neurological conditions. The subjects with parkinsonism were excluded because of their pathophysiology and in Parkinson disease it leads to rigidity rather than spasticity. All the other neurological conditions in which spasticity develops are included in the review. The various stretching techniques such as manual, mechanical, static, dynamic, short duration and long duration are included in the study. The stretching mo-

dalities like casting and stretching through weight bearing that is stretch in standing using tilt board or frame were included in the study. The patient with peripheral nerve injury and musculoskeletal diseases were excluded as well as the patient with cognitive and behavioral problems were also excluded.

A systematic literature search was evaluated through at least 28 articles related to effect of stretching on spasticity. Out of 28 articles we selected, 12 articles which were found suitable for reviewing the effect of stretching on spasticity in patients with neurological conditions. Among the 12 articles, eight studies were the randomized controlled trial, 3 studies were the single group experimental study and 1 study was comparative study. There were no case reports or case series were found in our selected literature search. These 12 articles were classified depending upon the population, methodology, intervention and outcome measure.

RESULT

We screened out 28 articles out of which we selected 12 good qualities of article which showed the significant effect in reducing spasticity by multiple techniques of stretching in different neurological conditions such as stroke, multiple sclerosis, spinal cord injury, cerebral palsy, traumatic brain injury. The age of patients was varied from 1 year to 79 years in the systematic review. The subject of eight articles were diagnosed with stroke, two studies included patient with cerebral palsy another two studies included with traumatic brain injury, one study included patient with spinal cord injury and multiple sclerosis.

Prolonged muscle stretching was given in five of the studies to biceps⁷, quadriceps²³ and ankle plantar flexor muscles. Passive stretching was included in the one of study to cerebral palsy patient.²⁶ In one of the article, stretching by resting hand splint was given to finger flexors in chronic hemiparetic patients for four weeks.¹⁶ There were two studies done which examined the immediate effect of single session of muscle stretching 20-30 minutes on hypertonic calf muscle.^{12,17-19,24}

One of article investigated the effect of isotonic and isokinetic muscle stretch on the excitability of the spinal α motor neuron in patients with muscles spasticity, in this randomized controlled trial, the experimental group included 66 stroke patients who have received a single session of 20 minute of isotonic or isokinetic muscle stretch with or without weight-bearing on the spastic ankle plantar flexors.

The result of this study showed a significant decrease in the spasticity.²² One of the article in which they investigated the comparison between sustained stretch to agonist muscle for one minute and quick icing to antagonist muscle for 10 minutes was done with the patients of chronic head injury. The result showed that prolonged sustained stretching has a significant impact on the reduction of tone according to Modified Ashworth scale. They concluded that sustained stretching on spastic agonist muscle is superior to quick icing on antagonist muscle.²⁵ Another study done on to investigate the efficacy of the myofascial release technique in comparison with passive stretching in reducing spasticity in cerebral palsy patients. They did randomized controlled trial in which study group received MFR technique to calf muscle and control group received passive stretching to calf muscle. Th outcome measures they used were GMFM and MAS. The result showed that both the treatment according to outcome measure showed significant improvement in reducing spasticity but the passive stretching group children showed more improvement in reducing spasticity and improvement in gait pattern. The study concluded based on the analysis of MAS, the passive stretching is superior than MFR.²⁶

All the articles which we reviewed included various outcome measures. Nine articles used MAS as an outcome measure for measuring grades of spasticity, five studies used PROM as an outcome measure, four studies used EMG parameters as an outcome measure and one article used a spatial temporal gait parameter. One of the study used the exaggerated stretch reflex to measure spasticity, the α motor neuron excitability was assessed by measuring the latency of the Hoffmann reflex (H-reflex) and the ratio (Hmax:Mmax) of the amplitude of the H max to that of the maximum response of the spastic soleus muscle (M max) .

In this study the result showed that there was reduction in Hmax: Mmax ratio which represents that there was reduction in spasticity after the intervention of stretching.¹² One of the study used a computerized laboratory gait analysis to measure the kinetic, kinematic and spatio-temporal parameters whose changes resulted from a single session of isokinetic or isotonic muscle stretching on gait.²²

The articles which included in the review are eight studies were the randomized controlled trial, 3 studies were the single group experimental study and 1 study was comparative study. There were no case reports or case series were found in our literature search. All type of stretching technique including mechanical and manual were used in the studies. Mainly stretching was the independent variable in all studies and the type of stretching and the stretching time which used was up to an average of 20–45 minutes and mainly the single session of stretching.

DISCUSSION

This systematic review mainly shows about the stretching and spasticity in neurological conditions. There are few studies which shows about the effect of stretching on spasticity. There is diversity at various levels such as in methodology, population, intervention, outcome measure. Our aim was to investigate the effect of stretching to reduce spasticity in neurological conditions. Stretching is one of the most commonly used interventions by physical therapist to reduce spasticity, including and to improve motor functions in patients with neurological conditions. As there are many stretching techniques which have been proposed and the general features of the stretching mainly intensity should be carefully examined, including the duration, repetition, and frequency. The spasticity reduction is considered one of the most desired outcomes in the rehabilitation in general and specifically after using stretching. Nine of the twelve studies used Modified Ashworth Scale as the outcome measure for spasticity. In all the four studies, there was an improvement that is there was seen reduction in spasticity level following the stretching. Another study also showed the same results, where they stated the two stretching protocols which showed the significantly improvement seen in the Modified Ashworth Scale and the Range of motion assessment results and there was reduction in the viscous and elastic component.

TABLE 1: SUMMARY OF EXPERIMENTAL STUDIES

STUDY	DESIGN	SUBJECT & TREATMENT	MUSCLE TARGET-ED	OUTCOME MEASURE	RESULT & CONCLU-SION
Barkha Khurana et al 2018	Comparative experimental	40 patients with chronic head injury (aged 25-50 yrs.) Grp A- Quick icing for 10 min on antagonist muscle Grp B – Prolonged stretch	Calf muscle	MAS	The authors concluded that prolonged sustained stretching have a significant impact on reduction of tone according to modified ashworth scale, the sustained stretching on spastic agonist muscle is superior to quick icing on antagonist muscle.
Urvashi Bhattacharya et al 2017	RCT	94 cerebral palsy patients (aged 12 months- 12 yrs.) Treatment- Intervention group- MFR on calf muscle Control group – Passive stretching to TA for 5 repetition for 6 days in a week for 4 weeks	Calf muscle	MAS GMFM ROM of ankle dorsiflexion	The authors concluded that passive stretching was found to be more effective than MFR
Jang et al 2016	RCT	21- Chronic hemiparetic stroke patients IG-11, CG-10 Treatment- IG- Wrist and hand stretching device was used to give stretching, one session for performed for 14 minutes. The stretching was conducted 3 sessions/day, 6 days/week for 4 weeks. CG- Treatment was not given	Wrist and finger flexor	MAS, Fugl Meyer motor assessment scale, AROM	The author concluded that this stretching device is effective in spasticity reducing and motor function improvement
Eun Hyuk Kim et al 2013	RCT	15- chronic hemiparetic stroke patient IG- 8, CG- 7 (aged 29-72 yrs.) Treatment- Resting hand splint with hand & thumb stretcher given to finger flexor for 10 min twice daily for 4 weeks	Finger flexor	MAS	The authors concluded that the modified stretching device with the simplified stretching protocol effectively relieved hand spasticity in chronic hemiparetic stroke patients
Bakheit et al 2005	RCT	66 hemiplegic stroke patients and 21 healthy patients were divided into 2 groups Treatment- 20-min session of isotonic muscle stretch (with or without weight bearing) or isokinetic stretch was delivered to the ankle plantar flexors	Tendons- Achilles muscle	MAS EMG- H reflex, Amplitude of Hmax:Mmax ratio	They concluded that there was slight decrease in spasticity and there was decrease in H/ M ratio in patients with stroke
Maynard et al 2005	Randomized parallel group, Prospective	66 hemiplegic stroke patients (3 groups), 21 healthy control subjects Treatment- 20-minutes single session of isotonic muscle stretch or isokinetic stretch were delivered to the ankle plantar flexors with or without weight-bearing	Calf muscle	Selected kinematic, kinetic and spatio-temporal gait parameters and measured at baseline, immediately after the muscle stretch & 24 hours later by using the Cartesian Optoelectronic Dynamic Anthropometer	Statistically significant difference between the patient groups and the healthy subjects on most of the gait parameters studied.

STUDY	DESIGN	SUBJECT & TREATMENT	MUSCLE TARGETED	OUTCOME MEASURE	RESULT & CONCLUSION
Yeh et al 2005	RCT	30 patients with Stroke were included Treatment – Prolonged mechanical ankle stretch was given for 30 minutes	Calf muscle	MAS ROM	The result showed that there was significantly decrease in MAS and significantly increase in ROM.
Yeh et al 2004	Single group pre-test- post test	25 patients with spastic hemiplegia were included. Treatment- Ankle planter flexors stretched in one session for 30 minutes was given	Calf muscle	MAS PROM	They concluded that MAS & PROM significantly improved.
Hui-Yi Chang et al 2001	(single group experimental study)	17 patients (aged 33-79 yrs.) of Spastic Hemiplegia Treatment- Prolonged muscle stretch to triceps surae muscle was given by making patient stand with dorsiflexed feet on tilt table for 30 minutes	Triiceps surae muscle	MAS H/M ratio of triiceps surae, F/M ratio of TA PROM of ankle dorsiflexion	The result showed that passive ROM was increased significantly & 30 minutes of Prolonged muscle stretch was effective in reducing motor neuron
Harvey et al 2000	RCT	14 SCI subjects with paraplegia and quadriplegia were included Treatment- Ankle was stretched into dorsiflexion for 30 minutes per day for 4 weeks	Gas-trocnemius muscle	Passive ROM	The authors concluded that stretching is effective measure to reduce spasticity in patients with spinal cord injury
N. Hassan et al 1995	(single group experimental study)	16 patients with mild to moderate spasticity in stroke patients (aged 32-79 yrs.) Treatment- Prolonged mechanical stretch to biceps muscle	Biceps muscle	MAS EMG- Amplitude	The authors suggested that sustained stretch is useful and practical method to reduce muscle tone in patients with spastic arm muscles.
Hale et al 1995	RCT	23 patients with Stroke, 2 with head injury and 1 patient with multiple sclerosis with spasticity of one or both quadriceps muscles were included in the study. Treatment- Prolonged muscle stretch for 2, 10, 30 minutes was given. Stretch at constant angle was given. The mechanical stretch was given to quadriceps muscle by isokinetic dynamometer for single session.	Quad-riceps muscle including rectus femoris muscle	MAS Knee flexion & extension performance test Pendulum test with Cybex	

In one of the study the author had found that the reduction in spasticity measured by MAS was because of a mechanism rather than the direct effect on α motor neuron. They suggested that an exaggerated stretch reflex is the characteristic of muscle spasticity and is primarily because of increased α motor neuron excitability.

One of the study done by Yeh et al on the effect of single session of prolonged muscle stretch on spastic muscle of stroke patients. The outcome measure they used were the MAS, passive range of motion of ankle dorsiflexion, maximum amplitude of H reflex of soleus muscle and F wave of TA muscle. The result showed that there was a significant increase in the ROM of ankle dorsiflexion after 30 minutes of prolonged muscle stretching and it occur due to the motoneuron excitability of the triceps surae muscle decreased after a prolonged muscle stretch. There were changes seen in the H reflex values due to the Ib afferent fibers in this case, the Golgi tendon organ was fired while stretching the calf muscle. Then the impulse was transmitted by the Ib afferent fiber through the interneuron thus, inhibiting the α motor neuron and another reason was may be due to the II afferent fiber in this case, the muscle spindle of the calf muscle was fired during the muscle was being stretched which in turn causes the impulse to get transmitted by the II afferent fiber through the spinal cord, thus, inhibiting the neuron excitability of α motor neuron.¹³

There are few studies done which examine the changes in the motor neural excitability after stretching. Rochester et al compared eccentric contraction along with muscle stretch to eccentric contraction alone in healthy subjects compared with neurological conditions patients which caused ankle spasticity. The neurological patients who received eccentric contraction showed significant and increase in Hoffman reflex when compared to healthy individual and there was no significant decrease in the mean amplitude of H reflex after the eccentric contraction along with muscle stretch intervention. So, the authors concluded that the application of the stretch along with eccentric contraction decreases the motor neuron excitability which may result in decrease in spasticity.¹⁷

Al-Zamil et al done the study to see the effect of sustained continuous mechanical stretch on elbow flexor spasticity,

the outcome measure they used to check the reduction of spasticity was measured as decrease in amplitude of EMG response to passive stretch. The result showed that in all patients it was observed that there was marked decrease in the amplitude of the EMG response and higher threshold to mechanical stretch. The mechanism which resulted in the decrease in spasticity was based on fatiguing of the flexor muscles of the forearm.⁷

There were few studies done to investigate the effect of stretching on the muscle viscoelastic properties, stiffness and range of motion in neurological conditions patients with spasticity. One of the author, Yeh et al compared the effectiveness of the constant torque prolonged muscle stretching with the constant angle prolonged muscle stretching treatment in the inhibition of the ankle hyper-tonia in patients with stroke. They gave intervention by stretching the ankle plantar flexors by using motor driven stretching device. The outcome measure they used was Modified Ashworth Scale. The authors concluded that constant torque and constant angle each treatment reduces spasticity and improved ankle range of motion. Both the treatment was effective because of the torque applied on elastic and viscous properties of the muscle. The range of motion of the ankle was increased due to the stress relaxation phenomena, the skeletal muscle exhibited the creep or strain relaxation when constant load is applied.¹⁸

Mohamed Ali et al compared the effect of functional stretching exercise with the passive stretching exercise along with physical therapy program. They applied the functional stretching exercise and physical therapy program intervention to study group and control group received passive stretching exercise and physical therapy program. The stretching was given to hip flexors, hip adductors, hamstring and calf muscle. The outcome measured they used were H/M ratio, popliteal angle and gait parameter. The H reflex was used as standardized method for evaluation of spasticity. In their study they concluded that Functional stretching exercises were effectively used in rehabilitation of spastic diplegic children; it reduced H/M ratio, increased popliteal angle and improved gait.

These functional stretching exercises were used as outlined to treat the soft tissue flexibility problems during function training, stretching is applied in unique way depending on the conception of overcorrection of deformities and prolonged stretching helps to utilize the inhibitory effect of stretching in improving function training during physical therapy treatment in order to optimize motor performance.²⁰

Bakheit et al compared the impact of single session of isokinetic or isotonic muscle stretch on gait in patients with spastic hemiparesis. They gave 20 minutes of stretch to ankle plantar flexors and MAS was used to measure spasticity. They found that the reduction in spasticity which was measured by MAS, because of the mechanism rather than the direct effect on α motor neuron. They suggested that an exaggerated stretch reflex is the characteristic of muscle spasticity and is because of an increased α motor neuron excitability. They measure α motor neuron excitability by measuring the latency in the H-reflex and then the ratio of the amplitude of the maximum H-reflex (Hmax) to that of the maximum action motor potential of the soleus spastic muscles (Mmax). They concluded that muscle stretching reduces spasticity by neurophysiological mechanisms rather than the direct effect on the excitability of α motor neuron.¹²

A study by Yeh et al on the quantitative analysis of ankle hypertonia after prolonged stretch in subject with stroke stated that an application of prolonged muscle stretch for 30 minutes using a constant stretching force, approximately 80% of the torque measured at the maximal passive ROM dorsiflexion position, significantly reduces both components of the ankle joint torque. The results of the study showed that the application of PMS with a constant torque could reduce not only the elasticity of the hypertonic muscles, but also their viscosity in the stroke patients.²⁴

None of the authors discussed about the adverse events of stretching and its effects on spasticity. But there is one study done which explains about the adverse effect of stretching. The study included patient with traumatic brain injury who were diagnosed with complete rupture of semi-membranosus muscle which caused by stretching.

After reviewing all this studies, we have found that patient characteristics widely vary between and within all the studies. It all depend upon the neurological condition, nature, severity of the spasticity, it also depends upon the pathophysiology of the spasticity whether it originates from the spinal or brain level and according to it the effect of stretching varies.

CONCLUSION

This systematic review profound the information regarding the effect of stretching on spasticity. The studies included in the review shows a wide variety at the level of methodology, population, intervention and outcome measure. The further studies can be done to investigate the long-term effects of stretching to reduce spasticity.

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