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Effect of Cryotherapy to Relieve Spasticity in Neurological Conditions - A Systematic Review

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Abstract: ***Background: Cryotherapy is one of the modalities frequently used to inhibit spasticity, the effect of which has been previously studied through the application of different measurements that show contradictory results. Objective: To investigate the literature evidence for the effect of Cryotherapy on spasticity in neurological conditions. Data Sources: This review contain latest literature, only Studies included within last 10 years. The keywords: Cryotherapy/ Cold therapy/Icing and spasticity, Physical therapy were entered into PubMed, Google scholar and Ovid databases, which included Medline, CINAHL, and Journals at Ovid full text, EBM reviews. Conclusion: Studies included in this review suggest that cryotherapy applied to the spastic muscles is effective in decreasing muscle tonus level.***

Keywords: Cryotherapy, Cold therapy, Icing, Spasticity, Physical therapy

1. Introduction

Spasticity is recognized as a phenomenon of velocity-dependent increases in tonic stretch reflexes with exaggerated tendon reflexes resulting from hyper excitability of the stretch reflex 0

Spasticity in particular is considered as an important symptom that can restrict a patient's functional abilities and reduce their quality of life. When it affects the lower limbs, spasticity may have negative effects on balance, mobility, and gait and may also increase the risk of (falls and fractures in people who have experienced a stroke.0

The search for effective, practical techniques to reduce the spasticity, thus aiding the individual to achieve more normal activity, is an ongoing process. Although many suggested techniques seem to be effective in a laboratory setting, careful and critical evaluation is necessary to determine whether each technique is effective when employed in a clinical or practical setting.[2]

Cold treatment is broadly utilized as a medicinal treatment and this strategy is utilized in the management of different acute and chronic conditions. There are many microscopic effects that are promoted by applying cold therapy such as reduced swelling and oedema in injuries, increased local circulation, decreased acute inflammation that follows tissue damage, decreased muscle spasm, and restriction of pain. [3]

Cold therapy can facilitate muscle contraction and can be used to improve muscle contraction to increase joint motion after injury. Another cold therapy impact is a period - related spasticity decrease once the ice has been applied for a long time. [3]

Cold therapy can be applied to the body in three different ways: submerge the part in cold water, scour ice cubes or ice packs, or use evaporative sprays like ethyl chloride.[3]

Eldred et.al- who reported that Ice application reduces muscle tone through a reduction of spindle sensitivity. They found that the rate of spontaneous spindle discharge decreases with decreasing temperature. [4], 5[7]

Michlovitz- stated that inhibition occurring due to the use of cryotherapy may be due to the local cooling effect on every component of the segmental sensorimotor complex including large afferent fibres of muscle spindle (both alpha and gamma motor neurons).[5], [7]

Cryotherapy is one of the modalities frequently used to inhibit spasticity, the effect of which has been previously studied through the application of different measurements that show contradictory results.[6]

Literature [7]-[17] reports that cryotherapy temporarily decreases spasticity, as well as deep tendon reflexes and clonus, due to decreased sensitivity of skin mechanoreceptors, slowed transmission of sensory and motor nerve fibres (alpha) or the decrease in the sensitivity to stretching of the neuromuscular spindle (NMH) and consequently, of the activity of the gamma system.

On the other hand, more recent studies [18]-[22] have established that the application of cryotherapy in the spastic person causes an increase in the maximum amplitude of the H response, in relation to the maximum amplitude of the M wave (Hmax / Mmax), suggesting reflex hyper excitability derived from the competitive effects of alpha and gamma motor neurons (MNs), caused by peripheral cooling.[23]

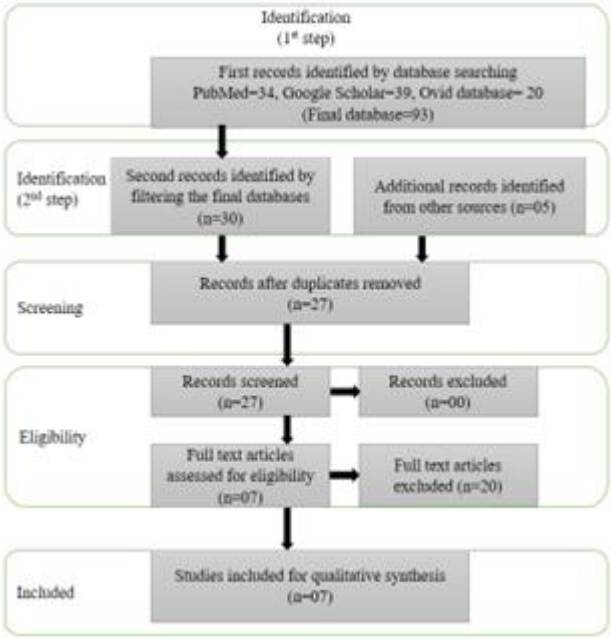
The aim of this study is to review the literature regarding the Cryotherapy to determine its effectiveness on spasticity.

2. Materials and Methods

This systematic review was carried out by using PubMed, Google scholar and Ovid databases, which included Medline, CINAHL, and Journals at Ovid full text, EBM reviews. We covered all the documents available on this

sources. We used the following indexing and text terms to search the data: Cryotherapy OR Cold therapy OR Icing, spasticity, Physical therapy.

The eligibility Criteria were: 1) Subjects diagnosed with spasticity from patients with hemiparesis. 2) Review contain latest literature, only Studies included within last 9 years i.e.2011-2019 3) Evaluation of spasticity level by means of qualitative (Ex- Modified Ashworth scale) and quantitative (Ex- dynamometric systems) methods. 5) Studies written in English. The studies that matched the criteria were subsequently examined for the inclusion.



3. Result

We screened out 30 articles out of which we selected 7 good qualities of article which showed the significant effect in reducing spasticity by various techniques of cryotherapy in different neurological conditions such as stroke, traumatic brain injury which leads to hemiparesis.

The age of patients was varied from 1 year to 75 years in the systematic review. The subject of five articles was diagnosed with stroke, another two studies included with traumatic brain injury.

Ice pack/Cold pack was given in four of the studies to Calf muscles (Plantar flexor muscles) for 20-30 minutes. Ice cube stroking, ice massage was given in four of the studies to Antagonist muscles, triceps surae, gastrocnemius muscles for 10-30 minutes in patients with hemiparesis secondary to stroke, and traumatic brain injury.

There was one study done which examined the immediate post 24 hours effect of cooling and sustained passive stretching as treatment techniques for reduction of spasticity in hemiplegics using H- reflex. The result of this study showed a significant decrease in the spasticity.[24]

One of the study done to investigate the effect of icing to reduce Spasticity, improving ankle range of motion and gait velocity in post stroke subjects. Total 30 participant who are hemiplegic patients with plantar flexor spasticity and walk independently were included. Result showed that icing decreases spasticity, and increases range of motion of ankle there by improving gait velocity.[25]

Summary Table

Study	Design	Subjects & Treatment	Outcome Measures	Results / Conclusions
Luccas Cavalcanti Garcia et. al. (2019)	A Randomized Sham-Controlled Crossover Study	16 chronic hemiparetic patients. Treatment- Group 1 receive cryotherapy for 20 mins on calf muscles, Group 2 receive conventional therapy.	A Biodex Multi-joint System 3 dynamometer, MAS	Cryotherapy temporarily reduces the degree of spasticity in the leg muscles without altering JPS in chronic hemiparetic stroke patients. These findings point to the efficacy of cryotherapy in reducing spasticity without affecting proprioception.
Carolina Carmona Alcantara et. al. (2019)	a randomized controlled crossover study	16 chronic hemi paretic subjects. (Aged 40-75 yrs.). Spasticity levels between 1 and 3 according to MAS on the ankle flexor muscles.	1) Modified Ashworth Scale; 2) isokinetic dynamometer 3) tridimensional movement analysis system (Qualisys).	Results: Cryotherapy decreased plantarflexor tonus but did not change muscle torque generation capacity and did not affect spatiotemporal or angular parameters during gait compared to control application. These findings contribute to the evidence-based approach to clinical rehabilitation post-stroke. Conclusions: The findings of this study suggest that cryotherapy applied to the calf muscles of subjects with chronic hemiparesis reduces muscle hypertonia but does not improve dorsiflexors and plantarflexors performance and gait parameters.
Mayerly C. Anaya N. et. al. (2016)	A randomized experimental study	15 subjects with spastic hemiparesis post-stroke were screened (mean age 60.7 ± 10.7 years) median of injury duration 36 months (IQR17-49). Treatment: : Experimental Group	Skin temperature (° centigrade), degree of resistance of the planter muscles to passive movement (Modified Ashworth	Conclusions: The study presented here is the first to establish the immediate effect of cryotherapy on spasticity, considering all the parameters evaluated by the H reflex. The results allow us to conclude that twenty minutes of cooling

		(GE) that received application of Ice Pack (PH) in cubes on the plantiflexers for 20 minutes and Control Group (GC) that remained at rest. Prone for 20 minutes.	Scale, EAM) and Reflex H parameters: latency (milliseconds), amplitude (millivolts), duration (milliseconds) and normalized amplitude index Hmax / Mmax (%).	on the calf muscles is useful to delay the response. Muscle evoked by direct electrical stimulation and reflex, therefore, the cubed PH can be a modality prescribed by physiotherapists for the temporary decrease of spasticity.
Jolanta Krukowska et .al. (2014)	An Experimental study	56 patients with post-stroke spasticity. They were divided into two groups (Group 1 was administered cryotherapy and kinesiotherapy and Group 2- kinesiotherapy only)	Modified Ashworth Scale, Brunnström Scale	**Results:** In the treatment groups decreased muscle tone. An improvement of the efficiency of locomotion and hand in performing activities of daily living. More favourable results were observed in group 1. **Conclusions:** Local cryotherapy combined with kinesitherapy appeared to be more effective in treating spasticity rather than kinesitherapy alone. A decrease in spasticity and an improvement of the limb function indicate a stabilization of muscular tension in patients with disorders upper motor neuron.
Dr. Barkhakhurana et al. (2018)	Comparative experimental study.	40 patient having tone of at least 3 or more on MAS of upper limb, (Aged 25 - 50 male and female, GCS 9 or below 9) Treatment: The patient was divided into two groups, group A and group B .In each group 20 patients were taken. Treatment was given for 6 days a week for 1 month in each group. Group A was treated with quick icing for 10 minutes on antagonist muscle. Group B was treated with long duration sustained stretch up to duration of 1 min.	Modified Ashworth Scale,	This study thus concludes that prolonged sustained stretching have a significant impact on reduction of tone according to modified ashworth scale. The patient who received prolonged sustained stretching has better results. Thus groupB showed a significant reduction in tone as compared to group A Thus, concluded that sustained stretching on spastic agonist muscle is superior to quick icing on antagonist muscle.
Dr.Shrikant Darade (2015)	Experimental study	Total 30 participant who are hemiplegic patients with plantar flexor spasticity and walk Independently were included. Treatment- Ice cube was taken in a turkey towel exposing one surface, and stroked over gastro soleus slowly from origin to insertion, maintaining a continuous and direct contact for 30 minute	Modified Ashworth Scale, goneometry and velocity formula	It is concluded that icing decreases spasticity, and increases range of motion of ankle there by improving gait velocity.
Shilpa Khandare (2012)	Comparative experimental study	30 patients (male=21, female=09) were selected between the (aged 40-70 Yrs) with spastic hemiplegia due to cerebrovascular accident. they were divided into two groups with 15 patients in each group The affected side of the patient was considered as Study group A Cooling was given and Study group B Sustained Passive Stretching was given along with routine rehabilitation.	H reflex	Results: Our study did not find any statistically significant difference between cooling and sustained passive Stretching for reducing the hypertonicity in triceps surae muscles ($p<0.05$). Conclusion: It is concluded that Cooling and Sustained passive stretching both are equally effective in reducing spasticity of tricepsurae muscles in patient with hemiplegia.

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 hemiparesis secondary to chronic head injury. They concluded that sustained stretching on spastic agonist muscle is superior to quick icing on antagonist muscle. [26]

All the articles which we reviewed included various outcome measures. Six articles used MAS as an outcome measure for measuring grades of spasticity.one study used 'A Biodex Multi-joint System 3 dynamometer to assess the joint position sense'.0 Some of the studies use the goniometry to check the joint ROM [25] and use scale such as: Brunstrom scale.[27]

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).[6]

The articles included in this systematic review contain, 3 studies were the randomized controlled trial, 2 studies were the experimental study and 2 studies were comparative study. There were no case reports or case series were found in our selected literature search. Treatment time which used was up to an average of 15–35 minutes.

4. Discussion

Cryotherapy is one of the most commonly used interventions by physical therapist to reduce spasticity.

There are many possible underlying mechanisms that explain how cold therapy reduces spasticity. The first mechanism was explained by Eldred et al, Ottosn, and Knutsson and Mattsson who reported that ice application reduces muscle tone through a reduction of spindle sensitivity [4]. They found that the rate of spontaneous spindle discharge decreases with decreasing temperature. Also, the rate of discharge from the Golgi tendon organs was found to be temperature-dependent. The change in discharge of the muscle spindle may result from the effect of cold on extra fused muscle, the intrafusal fibres or the sensory endings. Similarly, Michlovitz et al. stated that inhibition occurring due to the use of cryotherapy may be due to the local cooling effect on every component of the segmental sensorimotor complex, including large afferent fibres of muscle spindles (both alpha and gamma motoneurons), all skin receptors, extrafusal muscle fibres and the myoneural junction. [5]

The second possible mechanism is explained by Lippold et al. who suggested that the effect of cold application is related to the role of change in membrane polarization. They found that hyperpolarization or low potassium concentration reduced or abolished spindle discharge. Also, their findings are in agreement with those of Eldred et al. and associates who concluded that the site of thermal effect is the sensory terminal itself and is likely to be the result of change in membrane stability similar to those included in axons by lowering the temperature. [7], [28]

Finally, Miglietta reported that clonus and spasticity are not abolished unless the muscle temperature drops significantly. He mentioned the possibility that sympathetic fibres stimulation by cold application not only produces vasoconstriction but also decreases spindle sensitivity. [7], [28]

This agrees with Urbscheit et al. who investigated the changes in H-response and the Achilles tendon jerk in hemiplegic patients after cold application. They found that the hemiplegic patients responded differently. The author suggested that local cooling might decrease, increase, or exert no effect on the spasticity.[7] The results of this study support the findings of Warren et al. who concluded that deep prolonged and penetrating cold could be used in therapy to induce relaxation. They attributed their findings to be due to lowering of the background level of stretch afferent input. They reported that deep cold (penetrating the muscle mass) produces cold block of the receptors or the afferent fibres themselves.

The previous work of Price et al. on the effect of cryotherapy on spasticity at the human ankle supports our results. They established that cryotherapy has an effect on reducing the path length, a parameter indicating the frequency dependent viscoelastic response at the ankle. High values of path length have been shown to be associated with the presence of spasticity. They recommended the use of cryotherapy for 1 h on the calf muscles aiming for spasticity reduction. [30]

The results of this study confirm the findings of Lehman and de Lateur who reported that cold application has been found useful to be used to reduce spasticity in upper motor neuron lesion and in muscle re-education to facilitate muscle contraction.[31]

One of the study done by LuccasCavalcanti Garcia et. al on the 'Cryotherapy Reduces Muscle Spasticity But Does Not Affect Proprioception in Ischemic Stroke'. The outcome measure they used were the A Biodex Multi-joint System 3 dynamometer, MAS. The result showed that cryotherapy temporarily reduces the degree of spasticity in the leg muscles without altering JPS in chronic hemi paretic stroke patients. It is important to highlight that the results observed in the present study specifically represent the effects of ice packs applied to the spastic muscle, which cannot be generalized to cryotherapy effects if they were applied to other areas, such as the joint.0

Another study done by Dr.ShrikantDarade et.al. On the topic 'Can icing is help to reduce Spasticity, improving ankle range of motion and gait velocity in post stroke subjects'. The outcome measure he used were Modified Ashworth Scale, goniometry and velocity formula. The result showed that icing decreases spasticity, and increases range of motion of ankle there by improving gait velocity. The stimulus produced by cold have an inhibitory effect on the alpha motor neuron pool, which ultimately reduce spasticity.[25]

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 cryotherapy whether it originates from the spinal or brain level and according to it the effect of icing varies.

5. Conclusion

This systematic review contains the information regarding the effect of the cryotherapy in patients with hemiparesis. Most of the studies included in this review suggest that cryotherapy applied to the spastic muscles is effective in decreasing muscle tonus level.

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Conflict of Interest- None Reported.

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